UNITED STATES

THE PANAMA CANAL

THE THIRD LOCKS PROJECT

FINAL REPORT ON MODIFIED THIRD LOCKS PROJECT

PART I - GENERAL

AUGUST 1944

DEPARTMENT OF OPERATION AND MAINTENANCE
SPECIAL ENGINEERING DIVISION
BALBOA HEIGHTS, CANAL ZONE

Nº 29

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PART I--GENERAL

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PART I--GENERAL

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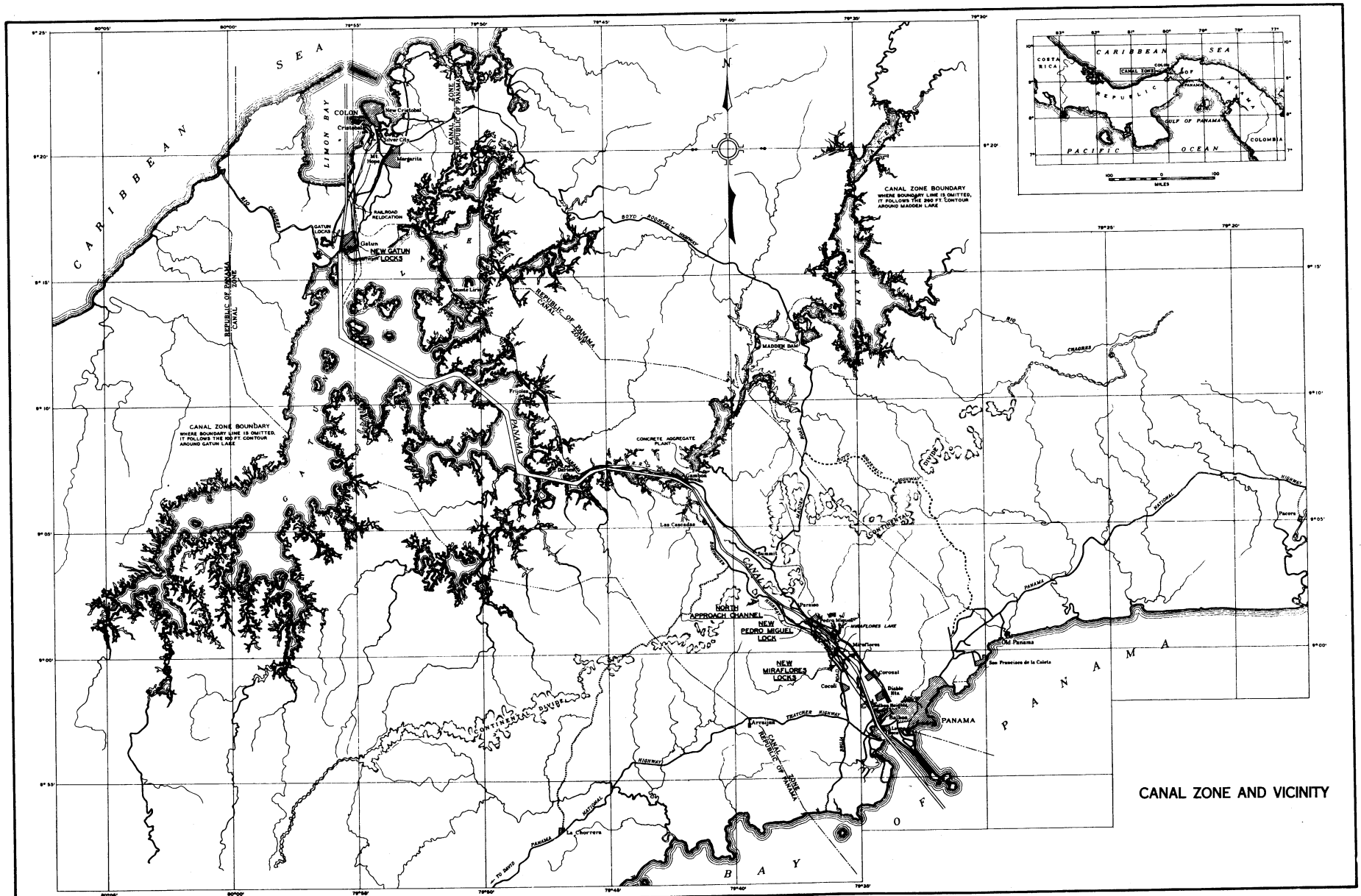


CANAL ZONE AND VICINITY

FINAL REPORT ON MODIFIED THIRD LOCKS PROJECT

PART I--GENERAL

INTRODUCTION

1. The construction of a third set of locks for the Panama Canal was authorized by Act of Congress, approved August 11, 1939. The first appropriation for their construction was contained in the War Department Civil Appropriation Act, 1941, approved June 24, 1940. The development of plans for detailed design and construction was accelerated and dredging was started when funds became available on July 1, 1940. As a result of the war and the needs created thereby for labor and materials, the construction program of the project was modified by directive of the Secretary of War dated May 25, 1942. The modified program provided for the deferment of major construction involving the use of critical materials, transportation and manpower, and the completion of certain features which were well advanced.

2. In view of the probable lapse of time between the completion of design and excavation under the modified program and the resumption of construction, it appeared very desirable to prepare a report on the work accomplished. This report has been made as complete and comprehensive as practicable, because most of the personnel concerned directly with the details probably will have left the Canal Zone when the work is resumed. Most of the sections of this report were prepared by persons thoroughly familiar with the developments, although there were cases where it was necessary in the interest of the war effort to release certain individuals before the report was completed. Many innovations in lock design were used as a result, in some cases, of the size of the structure and the necessity for reliable operation under all anticipated conditions and, in other cases, of the experience gained in the operation of the existing locks. An effort has been made to explain every important consideration involved in the adoption of the various features.

3. The report has been composed not only to serve as a record of what has been done, but to assist the organizations who will complete the construction and who will operate the new locks and maintain them in service. In general, the contents cover the work accomplished after receipt of construction funds, particularly after August 15, 1940, although much preliminary investigation and planning were done prior to that date. It has been divided into four major parts. Where indicated, the parts are accompanied by appendices and bibliographies for convenient reference. All the references shown are available in the record files.

Part I, General, gives a concise over-all description of the project, without much detail except where concerned with legislation, costs, and plans for resumption of construction operations.

Part II, Design, gives a detailed account of the design of all features. In addition to explanations of the adopted designs, it outlines briefly the investigations made on other designs considered. Each chapter is followed by a bibliography of more detailed reports and memoranda related to the subject matter.

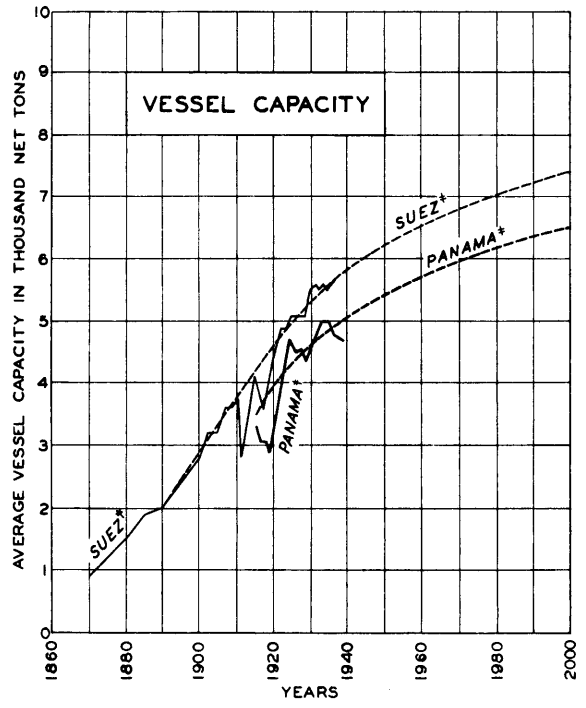
Part III, Construction, covers in detail the work accomplished to date and the methods employed. Of particular interest to the future organization are the chapters on Construction Planning and Concrete.

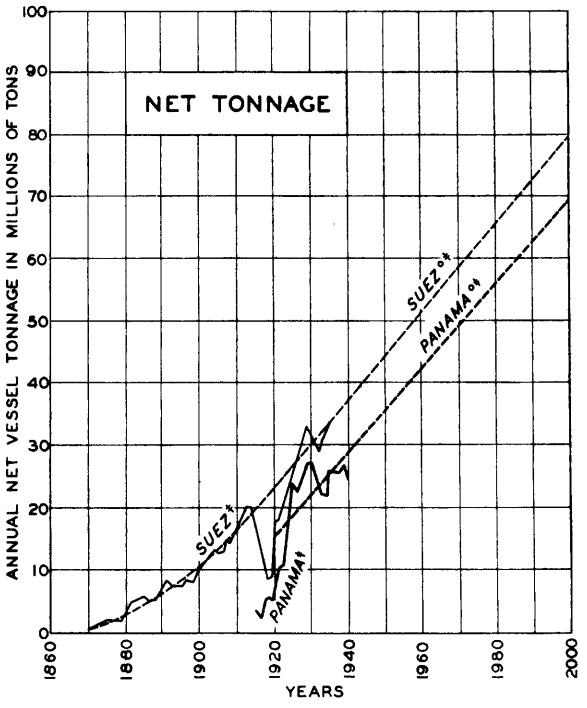
Part IV, Administration, covers in detail the work of the Administrative Section.

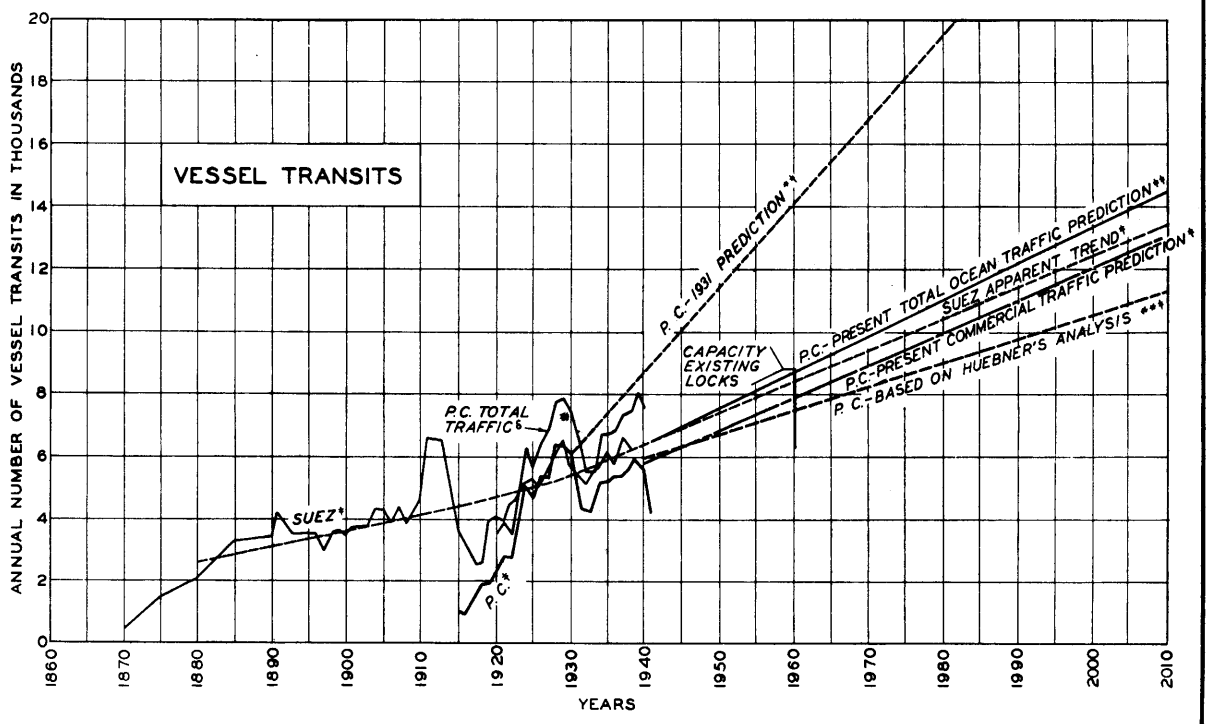
Early Studies

4. The eventual necessity for enlarging the facilities of the Panama Canal has been recognized since adoption of the original plans, and studies have been made at various times to determine when enlargement would be required. The existing Canal has certain physical limitations with respect to the number of lockages that can be performed in a 24-hour period, and with respect to the size of ships that can be transited. Table 1 shows the development of Canal traffic since it was opened August 15, 1914, and Figure 1 shows a current prediction of future traffic.

5. Much has been published concerning the importance of the Panama Canal in connection with the defense of the United States. The Army and Navy have for many years considered the problem of protecting the Canal, and various studies have been made with regard to the desirability and necessity of a second canal or the enlargement and additional protection of the existing Canal. Congress had been cognizant of the problem and by Public Resolution No. 99, 70th Congress, approved March 2, 1929, authorized the President "to cause to be made, under the direction of the Secretary of War and the supervision of the Chief of Engineers, and with the aid of such civilian engineers as the President shall deem advisable, a full and complete investigation and survey for the purpose of ascertaining the practicability and the approximate cost of constructing and maintaining (1) such additional locks and other facilities at the Panama Canal as may be necessary to provide for the future needs of interoceanic shipping; and (2) any other route for a ship canal between the Atlantic and Pacific Oceans." The Resolution specifically provided in part for a survey and report of a canal route across Nicaragua.







NOTE:

* DATA AND PREDICTIONS APPLY ONLY TO OCEAN-GOING COMMERCIAL TRAFFIC.
‡ INCLUDES 10% TO COVER ALL OCEAN-GOING TRAFFIC.
§ P.C. TOTAL TRAFFIC INCLUDES LOCAL BOATS

SOURCE OF DATA:

° "PANAMA CANAL TRAFFIC - 1936-1961 - REPORT AND ESTIMATE" BY GROVER G. HUEBNER.
* 1931 REPORT U.S. ARMY INTEROCEANIC CANAL BOARD
** NUMBER OF VESSELS EQUALS NET TONNAGE DIVIDED BY AVERAGE VESSEL CAPACITY.

THE THIRD LOCKS PROJECT

TRAFFIC PREDICTION

FIGURE 1

TABLE 1

DEVELOPMENT OF CANAL TRAFFIC BY FISCAL YEARS 1915 TO 1940

Fiscal Year Ended June 30-	Number of Transits	Panama Canal Net Tonnage (3)	Tolls	Tons of Cargo
1915 (1)	1,058	3,507,000	$ 4,366,747.13	4,888,400
1916 (2)	724	2,212,000	2,403,089.40	3,093,335
1917	1,738	5,357,000	5,620,799.83	7,054,720
1918	1,989	6,072,000	6,428,780.26	7,525,768
1919	1,948	5,658,000	6,164,290.79	6,910,097
1920	2,393	7,898,000	8,507,938.68	9,372,374
1921	2,791	10,550,000	11,268,681.46	11,595,971
1922	2,665	10,556,000	11,191,828.56	10,882,607
1923	3,908	17,206,000	17,504,027.19	19,566,429
1924	5,158	24,181,000	24,284,659.92	26,993,167
1925	4,592	21,134,000	21,393,718.01	23,956,549
1926	5,087	22,906,000	22,919,931.89	26,030,016
1927	5,293	24,245,000	24,212,250.61	27,733,555
1928	6,253	27,229,000	26,922,200.75	29,615,651
1929	6,289	27,585,000	27,111,125.47	30,647,768
1930	6,027	27,716,000	27,059,998.94	30,018,429
1931	5,370	25,690,000	24,624,599.76	25,065,283
1932	4,362	21,842,000	20,694,704.61	19,798,986
1933	4,162	21,094,000	19,601,077.17	18,161,165
1934	5,234	26,410,000	24,047,183.44	24,704,009
1935	5,180	25,720,000	23,307,062.93	25,309,527
1936	5,382	25,923,000	23,479,114.21	26,505,943
1937	5,387	25,430,000	23,102,137.12	28,108,375
1938	5,524	25,950,383	23,169,888.70	27,385,924
1939	5,903	27,170,007	23,661,021.08	27,866,627
1940	5,370	24,144,366	21,144,675.36	27,299,016
Total	109,787	493,385,756	474,191,533.27	526,089,691

(1) Canal opened to traffic August 15, 1914

(2) Canal closed to traffic approximately 7 months of fiscal year by slides

(3) Panama Canal net tonnages prior to 1939 are estimated figures based on revised measurement rules that became effective March 1, 1938

6. In accordance with the legislation cited, two reports were prepared, one by the Governor of The Panama Canal, in which the construction of an additional set of locks and ultimate conversion of the Canal to sea level were considered; and another by Lieut. Colonel Dan I. Sultan, C.E., concerning the Nicaraguan route. At that time, it was estimated that a third set of locks at Panama would cost $140,000,000 and that to lower the Canal to sea level would cost about $1,000,000,000. The cost of the proposed Nicaraguan Canal was estimated at $697,000,000 plus $25,000,000 for rights, franchises, and lands. The maintenance cost of the Nicaraguan Canal was estimated at $10,800,000 a year.

7. The Interoceanic Canal Board reviewed the reports and visited the canal sites, and concluded that no immediate steps were then needed to provide increased facilities for passing water-borne traffic from ocean to ocean, and that the construction of a third set of locks and conversion of the Panama Canal into a sea-level canal was the most practical solution to the problem, but that favorable consideration should be given to the Nicaraguan Canal at some later date, because of certain advantages to be derived from its geographical location and from the existence of two canals.

8. Nicaraguan Canal. The route considered most practical for an interoceanic ship canal across the Republic of Nicaragua was from Greytown, on the Atlantic Coast, to Brito, on the Pacific Coast, by way of the Deseado and San Juan Rivers and Lake Nicaragua. The Nicaraguan Canal would be 173 miles long, as compared with 51 miles for the Panama Canal. Like the Panama Canal, three pairs of locks near each coast would be necessary to lift ships to the elevation of the lake surface, 105 to 110 feet above sea level. For 70 miles the canal would be through Lake Nicaragua. The lock size and canal cross section were the same as those considered for the Third Locks at Panama. It was estimated that the Nicaraguan Canal would have an annual shipping capacity of about 80,000,000 tons. The construction, operation, and maintenance of the canal would require about the same facilities and installations as those now existing at the Panama Canal.

9. Enlargement of the Panama Canal. The Report of the Governor of The Panama Canal, dated August 4, 1931, submitted in connection with the studies authorized by the Act of 1929, considered a project for a third set of locks and a project for converting the Panama Canal into a sea-level canal. The report held that a third set of locks would not be needed until about 1970, and that these locks would be ample to care for increased shipping needs for a long future period. The third locks considered at that time were to be parallel and immediately adjacent to the existing locks. The length of the proposed new locks was 1200 feet, the width 125 feet, and the depth 42.5 feet. The shipping capacity of the new locks was estimated to be between 40,000,000 and 45,000,000 tons per year. The period of construction was estimated at 10 or 12 years.

A plan for lowering the Panama Canal to sea level was also presented in the report. It was estimated to require from 35 to 40 years for most economical construction, and it was regarded as essential to construct a third set of locks as a step in lowering the Canal to sea level. In view of the time required for conversion it was estimated that the project for lowering the Canal to sea level should start shortly after the completion of the third locks. Construction schedules were designed for lowering the Canal channel by dredging and for alternate lowering of various locks so that traffic through the Canal would be uninterrupted. The Governor recommended that no project for a sea-level canal at Panama be adopted then, and that tentative plans for the future should contemplate increasing the capacity of the lock canal by a third set of locks. The estimated cost of $140,000,000 for the third locks did not provide for locating the locks at some distance from the existing structures, as is now being done, nor did it provide for the size of locks now adopted and for the incorporation of defense features, now considered essential for the third locks.

10. By Public Resolution No. 85, 74th Congress, approved May 1, 1936, the Governor of The Panama Canal was "authorized and directed to investigate the means of increasing the capacity of the Panama Canal for future needs of interoceanic shipping, and to prepare designs and approximate estimates of cost of such additional locks or other structures and facilities as are needed for the purpose, and to make progress reports from time to time on the results thereof." In accordance with this legislation, the Governor of The Panama Canal submitted a report dated February 24, 1939, wherein it was considered that the construction of an additional system of locks should be started within 10 or 12 years on the basis of commercial requirements alone, and that naval use and defense considerations might dictate their earlier construction. Defense considerations caused the Governor to recommend that the new locks be constructed at some distance from the existing locks, thus requiring approach channels to connect with the existing waterway. The size of the proposed locks was 1200 feet by 135 feet in plan, with 45-foot depth. Because of the incorporation of defense features and the necessity of excavating approach channels, the estimated cost of the project was increased to $277,000,000.

LEGISLATION AND FUNDS

Authorization of Third Locks Construction

11. Construction of the Third Locks Project at a cost not to exceed $277,000,000 was authorized by an Act of Congress, (Public No. 391, 76th Congress) (Chap. 694, 1st Session) (H.R. 5129) approved August 11, 1939. The work was to be accomplished substantially in conformity with the report

of the Governor dated February 24, 1939. The act is quoted as follows:

"AN ACT Authorizing and providing for the construction of additional facilities on the Canal Zone for the purposes of more adequately providing for the defense of the Panama Canal and for increasing its capacity for the future needs of interoceanic shipping.

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the improvement and enlargement of the capacity of the Panama Canal in the interests of defense and interoceanic commerce is hereby authorized to be prosecuted by the Governor of the Panama Canal under the supervision of the Secretary of War, substantially in accordance with the plans set forth and recommended in the report of the Governor of the Panama Canal, dated February 24, 1939, and published as House Document Numbered 210 and including such appurtenant structures, works, and facilities, and enlargements or improvements of existing channels, structures, works, and facilities as may be deemed necessary at a total cost not to exceed $277,000,000, which is hereby authorized to be appropriated for the purpose: Provided, however, That all new personnel in such construction work occupying skilled, technical, clerical, administrative, and supervisory positions shall be citizens of the United States: Provided further, That the initial appropriation for the fiscal year 1940 shall not exceed $15,000,000. For the purposes aforesaid, the Governor of the Panama Canal is authorized (a) to employ such persons as he may deem necessary and to fix their compensation: Provided, That the compensation of such persons shall not be lower than the compensation paid for the same or similar services to other employees of the Panama Canal: Provided further, That rates of compensation in excess of those authorized by law for other employees of the Panama Canal shall not be paid without the approval of the Secretary of War: And provided further, That the Governor of the Panama Canal with the approval of the Secretary of War is authorized to engage under agreement when deemed necessary expert assistance in the various arts and sciences upon terms and rates of compensation for services and incidental expenses in excess of the maximum compensation provided by law for employees of the Panama Canal; (b) to authorize the making of contracts without the advertisement hereinafter prescribed, with architectural or engineering corporations, firms, or individuals for the production and delivery of designs, plans, drawings, and specifications; (c) to authorize the making of any and all contracts necessary for the prosecution of the work herein authorized; (d) to provide for the establishment and operation of such auxiliary plants and facilities in connection with the work as may be necessary or desirable; (e) to utilize any of the facilities or services of the Panama Railroad Company upon such terms and conditions as may be approved by the Secretary of War; and (f) in general to do all things

proper and necessary to insure the prompt and efficient completion of the work herein authorized.

"Notwithstanding any other provision of law, and except as otherwise provided in this Act, all purchases and contracts for supplies or for services, except for personal services, shall be made by the Panama Canal after advertising, in such manner and at such times, sufficiently in advance of opening of bids, as the Governor or his duly authorized representative in the United States shall determine to be adequate to insure notice and opportunity for competition. Such advertisement shall not be required, however, when (a) an emergency requires immediate delivery of the supplies or performance of the services; or (b) repair parts, accessories, supplemental equipment, or services are required for supplies or services previously furnished or contracted for; or (c) the aggregate amount involved in any purchase of supplies or procurement of services does not exceed $500; in which cases such purchases of supplies or procurement of services may be made in the open market in the manner common among businessmen. In comparing bids and in making awards the Governor or his duly authorized representative in the United States may consider such factors as relative quality and adaptability of supplies or services, the bidder's financial responsibility, skill, experience, record of integrity in dealing, and ability to furnish repairs and maintenance services, the time of delivery or performance offered, and whether the bidder has complied with the specifications.

"Approved, August 11, 1939."

Appropriations for Construction

12. Funds and contract authorizations for construction were appropriated and authorized as follows:

1. Public Law Number 653, 76th Congress, Chapter 415, 3rd Session, H.R. 8668, approved June 24, 1940, appropriated for the fiscal year 1941 an amount of $15,000,000 for construction, and authorized the entering into contractual obligations of $99,000,000 during the fiscal year 1941. Pertinent provisions of the Act are as follows:

"Construction of additional facilities--Panama Canal: For construction of additional facilities for the improvement and enlargement of the capacity of the Panama Canal, in accordance with the Act approved August 11, 1939 (53 Stat. 1409), including reimbursement to the appropriations 'Maintenance and Operation, Panama Canal', 'Sanitation, Panama Canal', and 'Civil Government, Panama Canal', in such amounts as the Governor of the Panama Canal shall from time to time determine to be additional costs incurred

for the objects specified in said appropriations on account of the prosecution of the work; in all, $15,000,000, and, in addition, the Governor of the Panama Canal may, when authorized by the Secretary of War, make or authorize the making of contracts prior to July 1, 1941, for or on account of the construction of such additional facilities, to an amount not in excess of $99,000,000."

"Sec. 2. No part of any appropriation contained in this Act shall be used directly or indirectly after May 1, 1941, except for temporary employment in case of emergency, for the payment of any civilian for services rendered by him on the Canal Zone while occupying a skilled, technical, clerical, administrative, executive, or supervisory position unless such person is a citizen of the United States of America or of the Republic of Panama: Provided, however, (1) That, notwithstanding the provision in the Act approved August 11, 1939 (53 Stat. 1409), limiting employment in the above-mentioned positions to citizens of the United States from and after the date of the approval of said Act, citizens of Panama may be employed in such positions; (2) that at no time shall the number of Panamanian citizens employed in the above-mentioned positions exceed the number of citizens of the United States so employed, if United States citizens are available in continental United States or on the Canal Zone; (3) that nothing in this Act shall prohibit the continued employment of any person who shall have rendered fifteen or more years of faithful and honorable service on the Canal Zone; (4) that in the selection of personnel for skilled, technical, administrative, clerical, supervisory, or executive positions, the controlling factors in filling these positions shall be efficiency, experience, training, and education; (5) that all citizens of Panama and the United States rendering skilled, technical, clerical, administrative, executive, or supervisory service on the Canal Zone under the terms of this Act (a) shall normally be employed not more than forty hours per week, (b) may receive as compensation equal rates of pay based upon rates paid for similar employment in continental United States plus 25 per centum; (6) this entire section shall apply only to persons employed in skilled, technical, clerical, administrative, executive, or supervisory positions on the Canal Zone directly or indirectly by any branch of the United States Government or by any corporation or company whose stock is owned wholly or in part by the United States Government: Provided further, That the President may suspend compliance with this section in time of war or national emergency if he should deem such course to be in the public interest.

"Sec. 3. The total amount used on an annual basis for administrative within-grade promotions for officers and employees under any appropriation or other fund made available in this Act shall not exceed the amount determined by the Bureau of the Budget to be available for such purpose on the basis of the Budget estimate for such appropriation or fund exclusive of new money in any such Budget estimate for such administrative promotions.

"Sec. 4. No part of any appropriation contained in this Act or authorized hereby to be expended shall be used to pay the compensation of any officer or employee of the Government of the United States, or of any agency the majority of the stock of which is owned by the Government of the United States, whose post of duty is in continental United States unless such person is a citizen of the United States, or a person in the service of the United States on the date of the approval of this Act who being eligible for citizenship had theretofore filed a declaration of intention to become a citizen or who owes allegiance to the United States.

"Sec. 5. This Act may be cited as the 'War Department Civil Appropriation Act, 1941'."

2. Public Law 71, 77th Congress, Chapter 130, 1st Session, H.R. 4183, appropriated $34,932,000 for the fiscal year 1942 for construction, and authorized the entering into contractual obligation during fiscal year 1942 for an amount of $79,000,000. Pertinent provisions of the Act are as follows:

"Construction of additional facilities--Panama Canal: For construction of additional facilities for the improvement and enlargement of the capacity of the Panama Canal, in accordance with the Act approved August 11, 1939 (53 Stat. 1409), including reimbursement to the appropriations 'Maintenance and Operation, Panama Canal', 'Sanitation, Panama Canal', and 'Civil Government, Panama Canal', in such amounts as the Governor of the Panama Canal shall from time to time determine to be additional costs incurred for the objects specified in said appropriations on account of the prosecution of the work; in all, $34,932,000, and, in addition, the Governor of the Panama Canal may, when authorized by the Secretary of War, make or authorize the making of contracts prior to July 1, 1942, for or on account of the construction of such additional facilities, to an amount not in excess of $79,000,000."

"Sec. 2. (Same as Sec. 2 of 1941 Act)

"Sec. 3. (Same as Sec. 4 of 1941 Act)

"Sec. 4. No part of any appropriation contained in this Act shall be used to pay the salary or wages of any person who advocates, or who is a member of an organization that advocates, the overthrow of the Government of the United States by force or violence: Provided, That for the purposes hereof an affidavit shall be considered prima facie evidence that the person making the affidavit does not advocate, and is not a member of an organization that advocates the overthrow of the Government of the United States by force or violence: Provided further, That any person who advocates, or who is a member of an organization that advocates, the overthrow of the Government of the United States by force or violence and accepts employment the salary

or wages for which are paid from any appropriation in this Act shall be guilty of a felony and, upon conviction, shall be fined not more than $1,000 or imprisoned for not more than one year, or both: Provided further, That the above penalty clause shall be in addition to, and not in substitution for, any other provisions of existing law.

"Sec. 5. This Act may be cited as the 'War Department Civil Appropriation Act, 1942'."

3. The Third Supplemental National Defense Appropriation Act, Bill H.R. 6159, authorized the entering into contractual obligations for an additional amount of $104,000,000 during fiscal years 1942 and 1943. Pertinent provisions of the Act are as follows:

"Construction, additional facilities, Panama Canal: In addition to the contract authorization in the amount of $79,000,000 contained in the War Department Civil Appropriation Act, 1942, the Governor of the Panama Canal may, when authorized by the Secretary of War, make or authorize the making of contracts prior to July 1, 1943, for or on account of the construction of additional facilities for the improvement and enlargement of the capacity of the Panama Canal, in accordance with the Act approved August 11, 1939 (53 Stat. 1409), in an amount not to exceed $104,000,000."

4. Public Law 527, 77th Congress, Chapter 246, 2d Session, H.R. 6736, appropriated for the fiscal year 1943 an amount of $56,826,800 for construction. Pertinent provisions of the 1943 Act are as follows:

"Construction of additional facilities--Panama Canal: For construction of additional facilities for the improvement and enlargement of the capacity of the Panama Canal, in accordance with the Act approved August 11, 1939 (53 Stat. 1409), including reimbursement to the appropriations 'Maintenance and Operation, Panama Canal', 'Sanitation, Panama Canal', and 'Civil Government, Panama Canal', in such amounts as the Governor of the Panama Canal shall from time to time determine to be additional costs incurred for the objects specified in said appropriations on account of the prosecution of the work; in all $56,826,800."

"Sec. 2. (Same as Sec. 2 of 1941 Act)

"Sec. 3. (Same as Sec. 4 of 1941 Act except last sentence quoted.) This section shall not apply to citizens of the Commonwealth of the Philippines.

"Sec. 4. (Same as Sec. 4 of 1942 Act)

"Sec. 5. The Governor of the Panama Canal is hereby authorized

to employ by contract or otherwise without reference to section 3709, Revised Statutes, and at such rates (not to exceed $50 per day for individuals) as he may determine, the services of architects, engineers, and other technical and professional personnel, or firms or corporations thereof, as may be necessary.

"Sec. 6. No part of any money appropriated by this Act or any other Act, except the appropriation 'Contingent expenses, Executive Office', and Acts making appropriations for the Military and Naval Establishments, shall be used for the purchase or exchange of any motor-propelled passenger-carrying vehicle without the specific approval of the Secretary of War.

"Sec. 7. This Act may be cited as the 'War Department Civil Appropriation Act, 1943'."

5. Public Law 357, 78th Congress, 2d Session, approved June 26, 1944, repealed the sum of $30,257,572 contained in the previous appropriations.

13. By Executive Order No. 8812, dated June 30, 1941, the President suspended, during the continuance of the unlimited national emergency proclaimed to exist by Proclamation No. 2487, dated May 27, 1941, compliance with Section 2 of the War Department Civil Appropriation Act, 1942, dated May 23, 1941. The suspension was continued for the duration of the present war by Executive Order No. 9359, dated July 1, 1943.

14. Based upon the recommendations of the Navy Department, the Governor, and the Secretary of War, the President on August 9, 1940 approved an increase in width of the Third Locks from the 135 feet contained in the basic report to 140 feet.

15. The appropriations and contract authorizations are summarized as follows:

Act	Appropriation	Contract Authorization
W.D. Civil Appr. Act, 1941	$15,000,000	$ 99,000,000
W.D. Civil Appr. Act, 1942	34,932,000	79,000,000
3rd Sup. Nat. Def. Act, 1942	- -	104,000,000*
W.D. Civil Appr. Act, 1943	56,826,800	- -
W.D. Civil Appr. Act, 1944	- -	- -
W.D. Civil Appr. Act, 1945	(-30,257,572)**	- -
Total	$76,501,228	

* For fiscal years 1942 and 1943
** Appropriation repealed

The funds appropriated were available until expended or repealed, but contract authorizations were applicable only for the fiscal years named.

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ORGANIZATION

16. The estimated date when additional facilities for commercial use would be needed has been shown to be between 1960 and 1970. The planning for development of additional facilities authorized by Public Resolution No. 85, 74th Congress, as stated in House Document No. 210, 76th Congress, 1st Session, "contemplated that the investigation be conducted with deliberation over a considerable period of time by a relatively small force, but at such a rate as would insure the completion of plans in time to begin construction 10 years before the locks would be needed," and that the needs of national defense might be such as to require construction of the additional lock system considerably ahead of the time when it would be required for commercial needs."

17. The unsettled conditions of other nations and the development of national defense facilities to meet such contingencies that might arise, particularly the defense of Panama Canal installations, led to the adoption of the project much earlier than that indicated by commercial requirements alone. The same conditions also led to adoption of a schedule for completion as rapidly as practicable.

18. The Special Engineering Section was established July 1, 1937, under the direction of the Designing Engineer, Mr. E. Sydney Randolph, to conduct the necessary field explorations and design. The name was changed to Special Engineering Division on July 22, 1939. The Special Construction Division was established September 25, 1939, under the direction of the Supervising Engineer, Colonel Thomas B. Larkin, after the project was authorized, to supervise the construction of the Third Locks and other special protective features planned for the existing installations. The heads of these two divisions reported to the Engineer of Maintenance.

19. Effective August 15, 1940, the design and construction organizations were merged into the Special Engineering Division and placed under the supervision of the Supervising Engineer, who reported to the Engineer of Maintenance. The positions of Governor and Engineer of Maintenance during the periods of preliminary planning and operations were occupied as follows:

Governor:
- Brigadier General Clarence S. Ridley (later Major General) until July 11, 1940.
- Major General Glen E. Edgerton until May 16, 1944.
- Major General Joseph C. Mehaffey from May 16, 1944.

Engineer of Maintenance:
- Colonel Glen E. Edgerton until July 11, 1940.
- Colonel Raymond A. Wheeler (later Lieutenant General) until September 1, 1941.
- Colonel James G. Steese until September 17, 1941.
- Brigadier General Joseph C. Mehaffey until May 16, 1944.
- Colonel Francis K. Newcomer from May 16, 1944.

The functions of the Division were:

1. Acting as an inspecting and coordinating agency, to insure the prosecution of the Third Locks Project in compliance with the plans and specifications, in coordination with other related work; at the required rate of progress, and in the most economical and efficient manner;

2. Preparation of contracts for work to be executed under its supervision, complete inspection of the work, preparation of estimates for payment under the contracts, and entire management and administration on the part of The Panama Canal of operations under each such contract;

3. Preparation of plans and specifications, consultations with and advice to other designing agencies in connection with plans and specifications for work to be performed under its supervision, whether by contract or otherwise; and

4. Such other work that might be assigned to it at various times.

20. The organization of the Special Engineering Division after August 15, 1940 was divided into three major sections: construction, design, and administration, under a Construction Engineer, a Designing Engineer, and an Executive Officer, respectively. The individuals occupying these positions during the various periods were as follows:

Supervising Engineer:
- Colonel Thomas B. Larkin (later Major General), until March 24, 1942*
- Colonel Hans Kramer (later Brigadier General), until September 10, 1942
- Colonel Charles H. Barth (later Brigadier General), until November 3, 1942**
- Mr. Edwin E. Abbott, after November 3, 1942

Construction Engineer:
- Colonel Hans Kramer, until March 25, 1942***
- Colonel Charles H. Barth, March 28 to July 1, 1942***
- Mr. Wendell E. Johnson, until April 1, 1943****

Designing Engineer:
- Mr. E. Sydney Randolph, until January 5, 1941
- Mr. Edwin E. Abbott, until November 3, 1942
- Mr. James E. Reeves, until December 14, 1943****

Executive Officer:
- Lieutenant Colonel Charles H. Barth, until March 28, 1942
- Major Thomas De F. Rogers (later Lieutenant Colonel), until May 20, 1942
- Major Ralph D. King (later Lieutenant Colonel) until June 30, 1942****

* Also Director of Civilian Defense, The Panama Canal, December 1941 to March 1942

** Also Director of Civilian Defense, The Panama Canal, March 1942 to November 1942

*** Also Assistant Supervising Engineer

**** Positions not filled after these dates due to imminence of completion of scheduled work.

(Mr. Lincoln J. Cotton was Administrative Assistant to the Executive Officers. Mr. Vincent W. Reynolds was Administrative Assistant until February 13, 1944, when he was succeeded by Mr. Thomas E. Smith.)

The Safety Section of The Panama Canal was created when the Special Engineering Division was organized, and since Third Locks operations would require a major portion of the safety program, the administration of the section was placed with the Special Engineering Division. An organization chart is shown in Figure 2. With minor modifications caused by changes in personnel or by greater emphasis on certain features of work, this chart is representative of the organization throughout the work. The forces of the three major units are shown graphically in Figure 3.

21. Employments for the Division were effected through the regular Panama Canal agencies. Contacts with prospective employees were effected through the Civil Service Commission, through personal correspondence, and by special representatives' direct contact at various universities and scheduled visits to various cities. In general, it took from 45 to 60 days for the arrival of an employee after his appointment.

22. The construction operations were divided between contract and hired-labor (Government force). The hired-labor work, which consisted of housing, municipal facilities, minor relocations, and dredging, was done by the appropriate regular Panama Canal Divisions. All major construction was designed for execution by contract under competitive bids.

23. Each regular construction division arranged for its labor and equipment through the existing Panama Canal agencies. The contractors employed their own labor either by direct recruitment or through and with the assistance of The Panama Canal. All employees were required to be "processed" or passed upon by The Panama Canal Central Labor Office.

24. Throughout the period of operation between July 1940 and the fall of 1943, there was a shortage of qualified labor on the Isthmus. Many operations of prime importance were in progress by hired-labor and by contractors, many of the latter working on a cost-plus-a-fixed-fee contract. To permit all operations to proceed in an orderly manner, the contractors and Government agencies cooperated to stabilize wage rates and to prevent "proselyting" among employers.

DESIGN

25. As previously mentioned, the early studies for enlarging the capacity of the Panama Canal involved the construction of additional

locks adjacent to the existing locks. The records and estimates indicate that the new structures were to be similar but larger than the existing ones. However, the project finally adopted provided that the structures be separated from the existing locks and that special features for protection be incorporated in the design. The maintenance of Gatun Lake and the transiting of ships without delay were the paramount objectives sought in the design of the Third Locks. These conditions required the inclusion in the lock structures of many new features that can be justified only by the intangible defense value of ensuring transits. Much study had been given to the features that would have been desirable in the existing locks, and this work furnished the general basis for detailed development and elaboration.

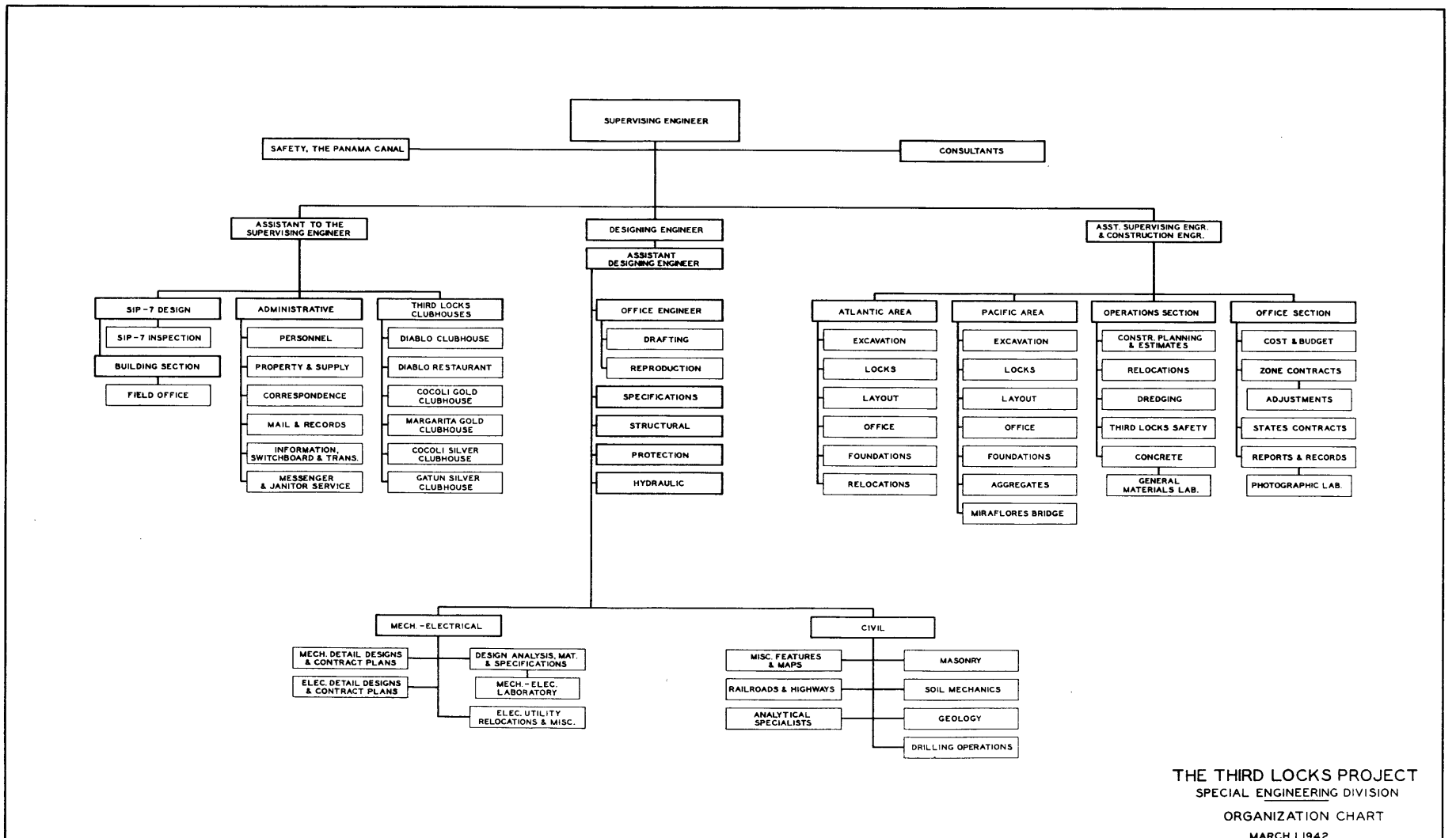
General Arrangement of Locks

26. The size of the lock chambers contemplated in the basic Act was 1200 feet in length, 135 feet in width, and 45 feet minimum depth. The width was increased later to 140 feet to provide for a more normal ratio of width to length in use on current design of large ships.

27. The length of 1200 feet is an effective or usable length. The over-all length of the lock chambers must be greater than the usable length to provide clearance for gates and other appurtenances. On the upstream side of a miter gate, a distance of 105 feet from the pintle is used for the safe operation of the gate. An additional distance of 50 feet is required for the operation of chain fenders. Therefore, where required, chain fenders are placed 155 feet upstream or 50 feet downstream from the pintles. The over-all length of a chamber thus is 1305 or 1355 feet. Chambers adjacent to lakes have sufficient length to permit the closure of duplicate gates ahead of a ship traveling in either direction. Duplicate gates in all gate bays permit transiting ships of at least 1000-foot length when one pair of gates is inoperable. The duplicate gates are 200 feet apart to safeguard against the possibility of simultaneous destruction of both gates. Figures 4, 5, and 6 show the gate arrangements at Gatun, Pedro Miguel, and Miraflores Locks, respectively.

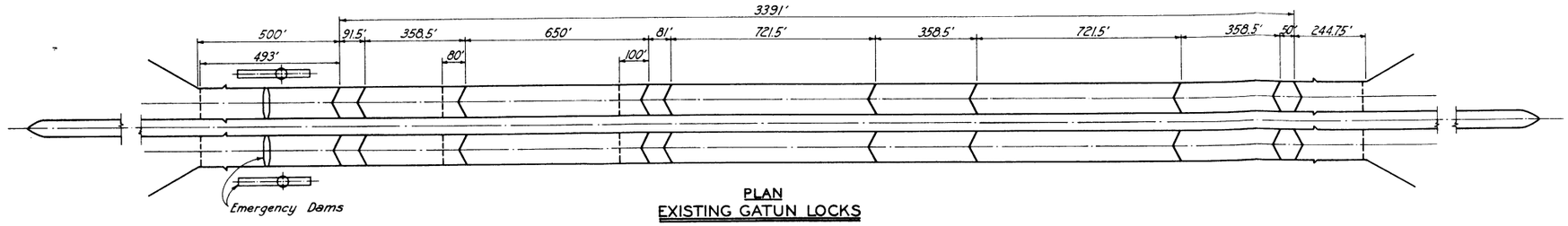
28. The required depth of 45 feet is interpreted as salt-water depth. The equivalent fresh-water depth is 46.9 feet. For design purposes, the operating range of Gatun Lake was fixed between elevations 80 and 87; that of Miraflores Lake, between elevations 53 and 54. The observed extremes of the Caribbean Sea, elevations 1.8 and -1.25, were adopted. Corresponding elevations adopted for the Pacific Ocean were 11.54 and -10.0. Terminal sills were allowed a 1-foot clearance. A 2-foot freeboard was provided above the highest static level at each gate.

29. When operations are in progress in all chambers in Gatun or Miraflores, it is convenient and economical in water to make the lockage in each chamber with the same amount of water (equal-prism lockage). By

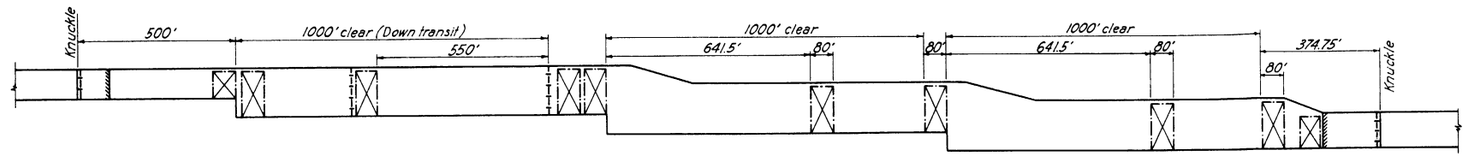


THE THIRD LOCKS PROJECT
SPECIAL ENGINEERING DIVISION
ORGANIZATION CHART
MARCH 1, 1942

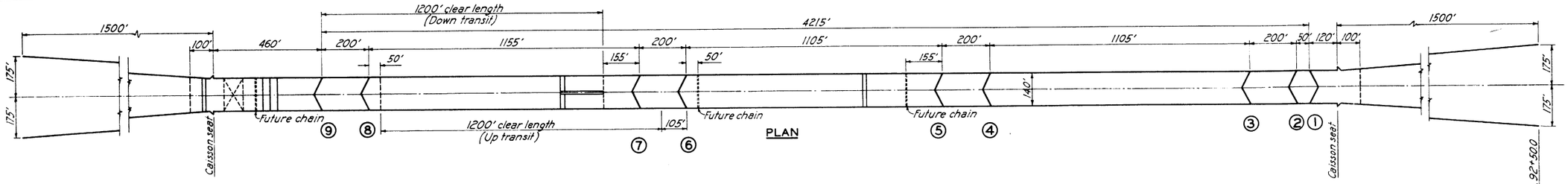
FIGURE 2



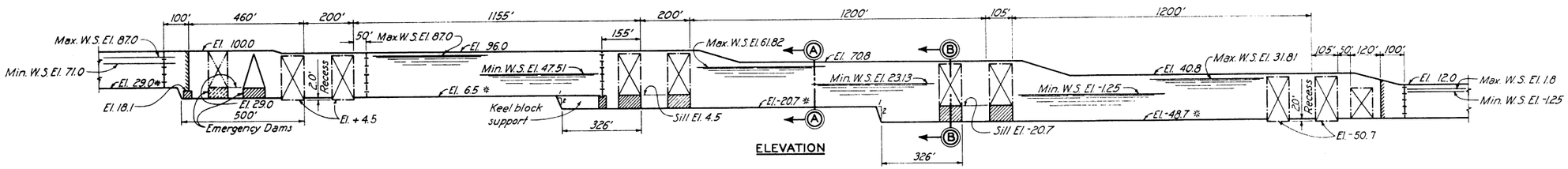
PLAN
EXISTING GATUN LOCKS



ELEVATION
EXISTING GATUN LOCKS

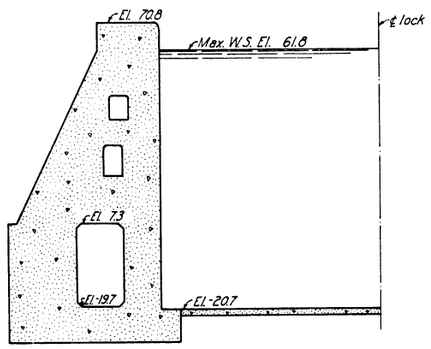


PLAN

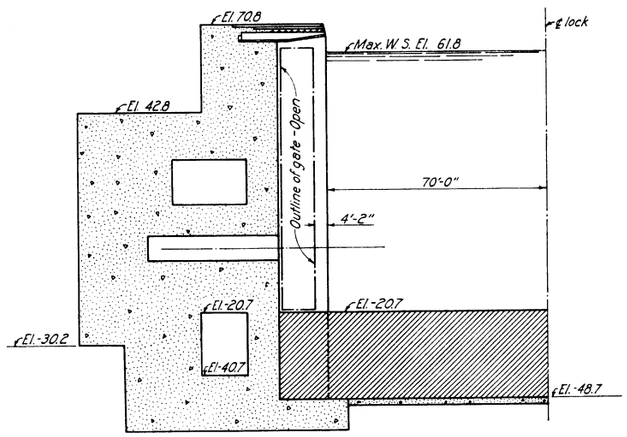


ELEVATION

NOTE:
* Controlling maximum elevations.



SECTION A-A

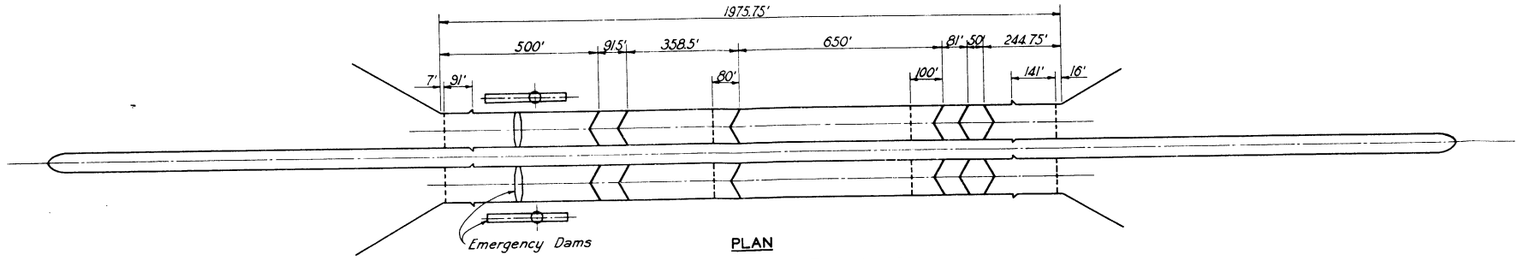


SECTION B-B

▨ To be removed during conversion.

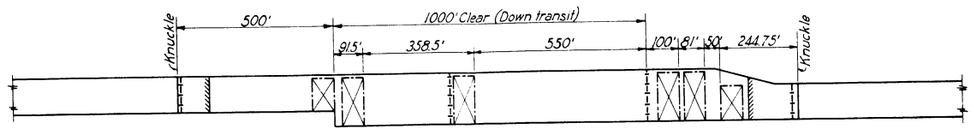
THE THIRD LOCKS PROJECT
NEW GATUN LOCKS
GATE ARRANGEMENT

FIGURE 4



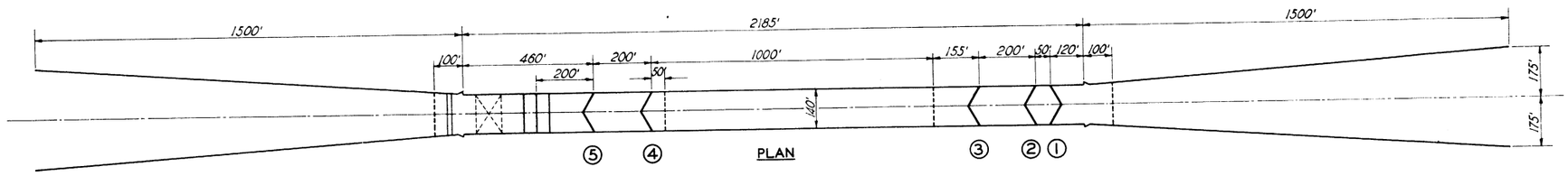
PLAN

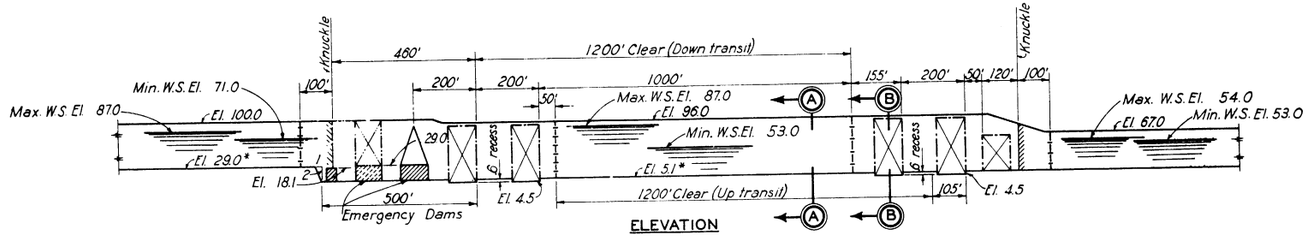
EXISTING PEDRO MIGUEL LOCKS



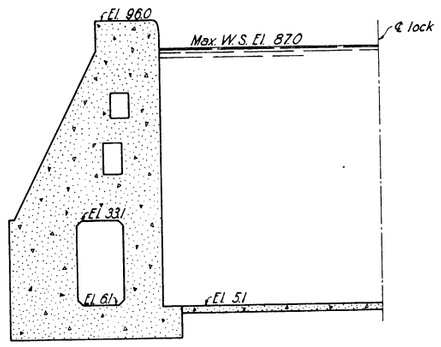
ELEVATION

EXISTING PEDRO MIGUEL LOCKS

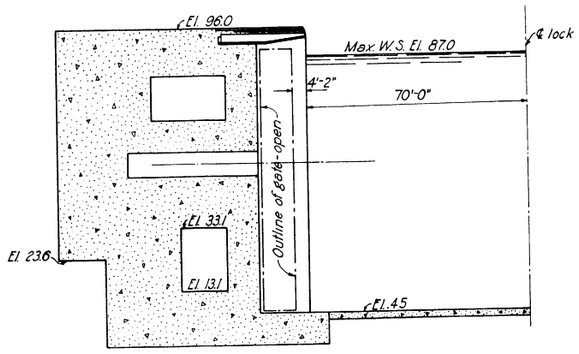




ELEVATION



SECTION A-A



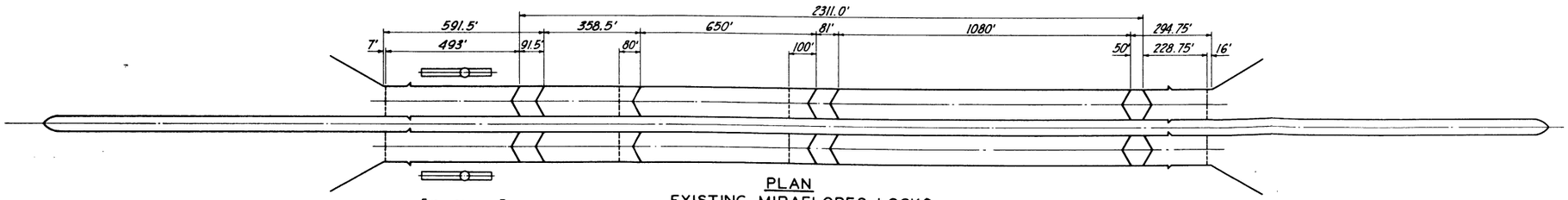
SECTION B-B

NOTE:

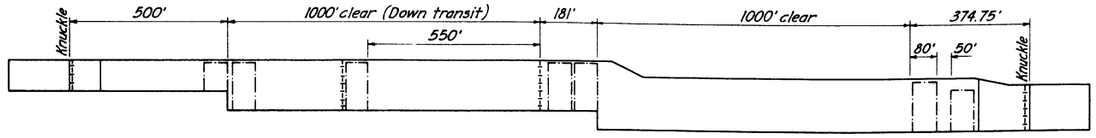
* Controlling maximum elevation.

THE THIRD LOCKS PROJECT
NEW PEDRO MIGUEL LOCK
GATE ARRANGEMENT

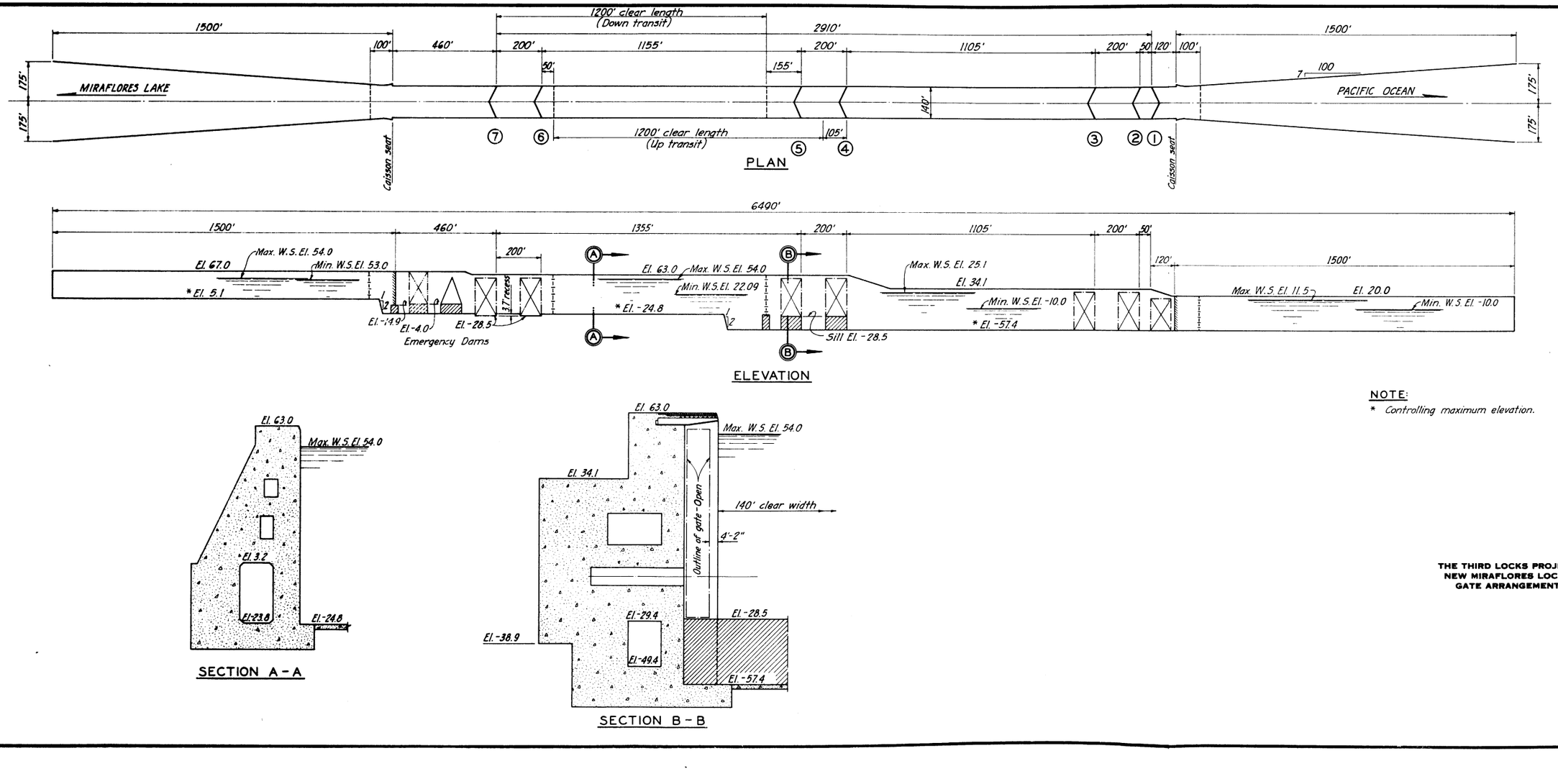
FIGURE 5



PLAN
EXISTING MIRAFLORES LOCKS



ELEVATION
EXISTING MIRAFLORES LOCKS



ELEVATION

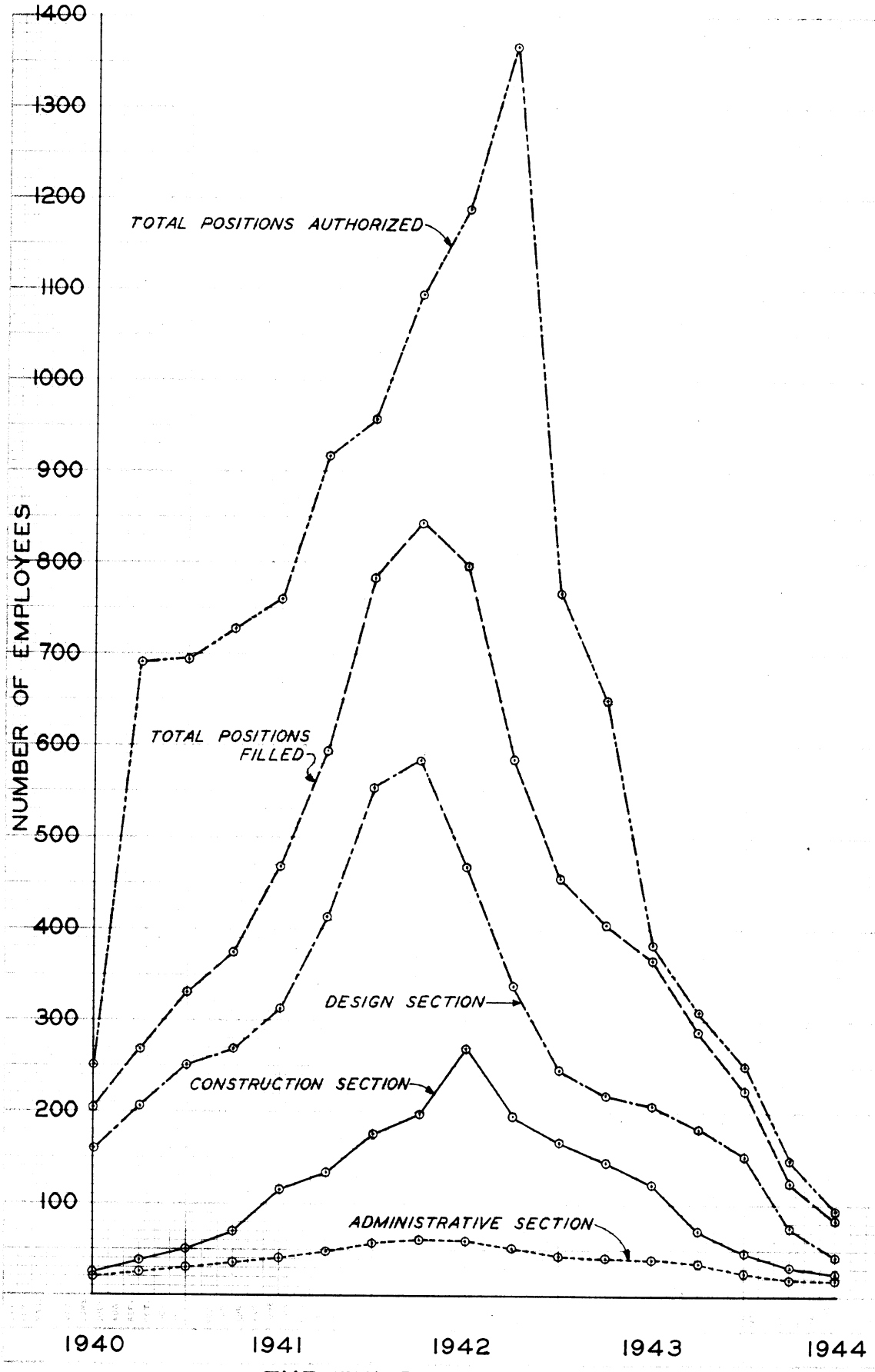
SECTION A - A

SECTION B - B

NOTE:
* Controlling maximum elevation.

THE THIRD LOCKS PROJECT
NEW MIRAFLORES LOCKS
GATE ARRANGEMENT

FIGURE 6



THE THIRD LOCKS PROJECT
GRAPH OF SPECIAL ENGINEERING DIVISION FORCES

FIGURE 3

assuming equal-prism lockages for normal gate operations, the sill elevations that will give the minimum draft may be fixed. The sill elevations at Pedro Miguel were fixed by the terminal levels.

30. The height of gates is normally governed by the difference between the sill elevation obtained with equal-prism lockages and the maximum static water level at each gate. However, with a slightly greater loss of water at certain tidal ranges at Miraflores and an adjustment of sill heights at a few other locations, it was possible to make all service gates 84.5 feet high. Such uniformity was considered very desirable to permit complete interchangeability of service gates, particularly in view of the installation facilities incorporated in their design. The unwatering gates, which are of less importance and are provided for maintenance only, vary from this height. The unwatering gate at Miraflores is 71.0 feet high; those at Gatun and Pedro Miguel are 52.5 feet high.

Geology

31. Present knowledge of Canal Zone geology has been accumulated from the work of many investigators, beginning with the studies of the French. Much data were compiled by the Isthmian Canal Commission, and especially the work of the late Dr. D. F. MacDonald from 1911 to 1913 and from 1938 to 1942 has proven of great value. Recent explorations, particularly the core borings, for the Third Locks Project have permitted closer definition of contacts and a more precise evaluation of the rock properties that are important in construction.

32. The topography of the region is largely the result of processes of differential erosion acting on the various rock types present. Where areas are underlain by soft rocks, generally of sedimentary origin, the surface consists of rolling hills separated by relatively wide valleys; conversely, where harder rocks are present, the valleys are much narrower. Hard rocks superimposed upon softer rocks have produced steep-sided hills of a distinctive conical shape. Along both coasts are swampy areas that were caused by periods of slow submergence and marginal filling. These areas have been raised subsequently to their present position a few feet above sea level.

33. The sedimentary formations present within the Canal Zone range in age from Oligocene to Recent. The Madden Lake area contains limestones and shales considered to be of upper Eocene age. In general, the oldest rocks are found near the center of the Isthmus and the rocks become progressively younger toward the coasts. A brief description follows of the most important formations, beginning with the oldest:

Basement Complex: Agglomerates, tuffs, fine-grained indurated sediments, basalts, and other igneous rocks that represent an unknown period of eruptive and intrusive igneous activity. The members are believed to be of lower Eocene age or older, although

these materials are of heterogeneous physical properties and none contain identifiable fossils that would permit an accurate age assignment.

Bohio Formation: Conglomerates, sandstones, and limestones found extensively in the central portions of the Canal Zone.

Culebra Formation: Middle Oligocene shales and argillaceous or calcareous sandstones of shallow-water marine deposition.

Emperador Limestone: Reef deposits of middle Oligocene limestone irregularly interspersed through the upper horizons of the Culebra formation.

Cucaracha Formation: Argillaceous shales, sandstones, and conglomerates of upper middle Oligocene age. Largely of terrestrial origin.

La Boca Formation (formerly referred to as Upper Culebra): Marine-deposited, upper Oligocene, fossiliferous sandstones and shales that overlie the Cucaracha formation. These beds were formerly included with the Culebra.

Pedro Miguel Agglomerate: Basaltic, pyroclastic rocks above the Cucaracha and below the La Boca.

Caimito Formation: Limy, marine-deposited sandstones, tuffs, and shales of lower Miocene age.

Gatun Formation: Argillaceous, variably limy, fine-grained sandstones, tuffs, and conglomerates of middle Miocene age found extensively on the Atlantic coast.

Panama Tuff: Marine- and land-deposited tuffs and tuffaceous sandstones present near Balboa Bay.

Toro Limestone: Cemented beds of fragmented shells with interlayered sandy members. Overlies the Gatun formation southwest of Limon Bay.

Chagres Sandstone: Argillaceous, massively bedded sandstones containing a sparse fossil fauna indicative of uppermost Miocene or lower Pliocene age.

Atlantic and Pacific Mucks: Littoral swamp deposits filling irregularities created along both coasts during a period of Pliocene emergence.

Alluvium, Residual Soils, and Fill: Recent products of stream deposition, such as gravels, sands, and silts; soil resulting from

in-place decomposition of rocks; spoil from previous construction activities.

Igneous Rocks: Basalts, andesites, rhyolites, and other intrusive or extrusive types are widely distributed.

34. The structure is that of a complex, faulted anticline with the older formations in the central part. The axial trend is dominantly northeast-southwest, but the true structural picture is locally clouded by the presence of minor warps and large faults. The present appearance of the land surface was caused by epeirogenic movements that date back to early Miocene. The rising or sinking of the land with changes in the rate of erosional and depositional activity can be detected from present features. The construction of the Canal, through the creation of Gatun and Miraflores Lakes and the imposition of large quantities of excavation spoil in certain areas, has modified to a large extent the natural topographic features.

Location of Locks and By-Pass Channels

35. The final location of the locks was controlled by the topography and the geology of the sites in the general location selected under the preliminary studies. All locks were placed a distance from the existing locks so as to decrease the probability of more than one lock being rendered inoperative by any one given cause. The alignment of the by-pass channels was determined mainly on the basis of navigational requirements. Figures 7 and 8 show the general locations selected and their relation to the existing locks.

36. The south by-pass channel to the new Gatun Locks forms an angle of 18°44'06" with the Canal. The north by-pass channel forms an angle of 29°37'36". The total length of the alignment for the new locks is 30,663.16 feet, of which 7795 feet is occupied by the lock structures.

37. The south by-pass channel to the new Miraflores Locks forms an angle of 12°52'50" with the Canal. The north by-pass channel meets the Canal in Miraflores Lake. The total length of the new alignment is 21,130.5 feet, of which 6490 feet is occupied by the lock structures.

38. The Pedro Miguel south by-pass meets the Canal axis in Miraflores Lake and forms an angle of 37°20'18" with the alignment of the Miraflores north approach. The locks are located on the south-approach alignment. The north by-pass forms angles of 28°58'56" with the Canal alignment and of 46°16'58" with the south by-pass alignment. The total length of the new alignment is 15,647.8 feet, of which the lock structures occupy 5185 feet.

39. All approach channels are 500 feet wide except a short reach in the north approach of Pedro Miguel Lock which is 300 feet, and are of

sufficient length to eliminate practically all hazard in entering or leaving the locks.

Foundations and Slopes

40. The results of subsurface explorations made throughout the areas occupied by the Third Locks are shown on geologic area maps and by transverse and longitudinal sections for each lock location. Field and laboratory tests were conducted on all materials to be used as foundations for lock structures and through which cuts were to be made.

41. Conditions at each lock site vary considerably. At Gatun the structural geology is very simple, and the locks will be founded on Gatun sandstone. There are no complicated foundation or slope problems in the rock, but the soft "muck" in low areas presented a slope problem. At Miraflores, the foundation consists of sound but columnar basalt, except (1) a part of the left south approach wall and (2) the north approach walls. The north approach walls will rest on piers and caissons carried to firm weathered rock. The most complex foundation problems were encountered at Pedro Miguel. Here the approach walls will rest mostly on various beds of the Cucaracha formation, and the locks will rest on agglomerate and the Culebra formation.

42. The excavation slopes were designed for each of the several materials including allowances for character of overburden and depths of cut. The established slopes varied over a wide range. Particular attention was given the Gatun "black muck" and the Cucaracha formation which had proven so troublesome during the original construction of the Canal. The results of these studies for the respective materials and conditions are shown on the contract plans.

43. Allowable foundation bearing and shear values were established for the various materials where required. As a result of field and laboratory tests, the following bearing values were used:

Gatun Sandstone	20 tons per square foot
Culebra	15 tons per square foot
Cucaracha	8 tons per square foot
Basalt and Agglomerate	36 tons per square foot

44. In addition to the studies made for the locks proper, other studies were made for miscellaneous features such as land plugs, relocations of highways and railroads, bridges, docks, spoil areas, backfill, drainage, and power plants.

Hydraulic Design

45. In view of the necessity of centering ships in the lock

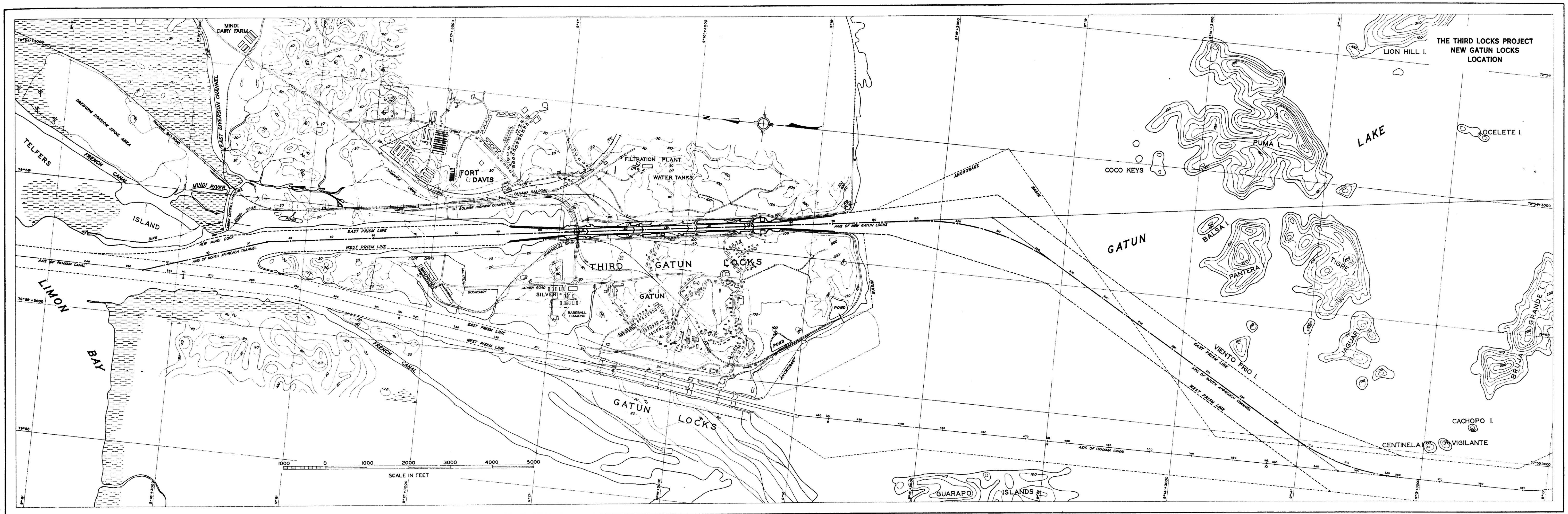

THE THIRD LOCKS PROJECT
NEW GATUN LOCKS
LOCATION
MINDI DAIRY FARM
EAST DIVERSION CHANNEL
TELFERS
FRENCH CANAL
MINDI RIVER
ISLAND
FORT DAVIS
FILTRATION PLANT
WATER TANKS
EAST PRISM LINE
WEST PRISM LINE
AXIS OF NEW GATUN LOCKS
THIRD GATUN LOCKS
SILVER
GATUN
BASEBALL DIAMOND
POND
LIMON BAY
GATUN LOCKS
GATUN LAKE
LION HILL I.
OCELETE I.
COCO KEYS
PUMA
BALSA I.
PANTERA
TIGRE
JAGUAR I.
VIENTO FRIO I.
BRUJA
GRANDE I.
CACHOPO I.
CENTINELA
VIGILANTE
GUARAPO ISLANDS
1000 0 1000 2000 3000 4000 5000
SCALE IN FEET

FIGURE 7

THE THIRD LOCKS PROJECT
NEW PEDRO MIGUEL AND MIRAFLORES LOCKS
LOCATION

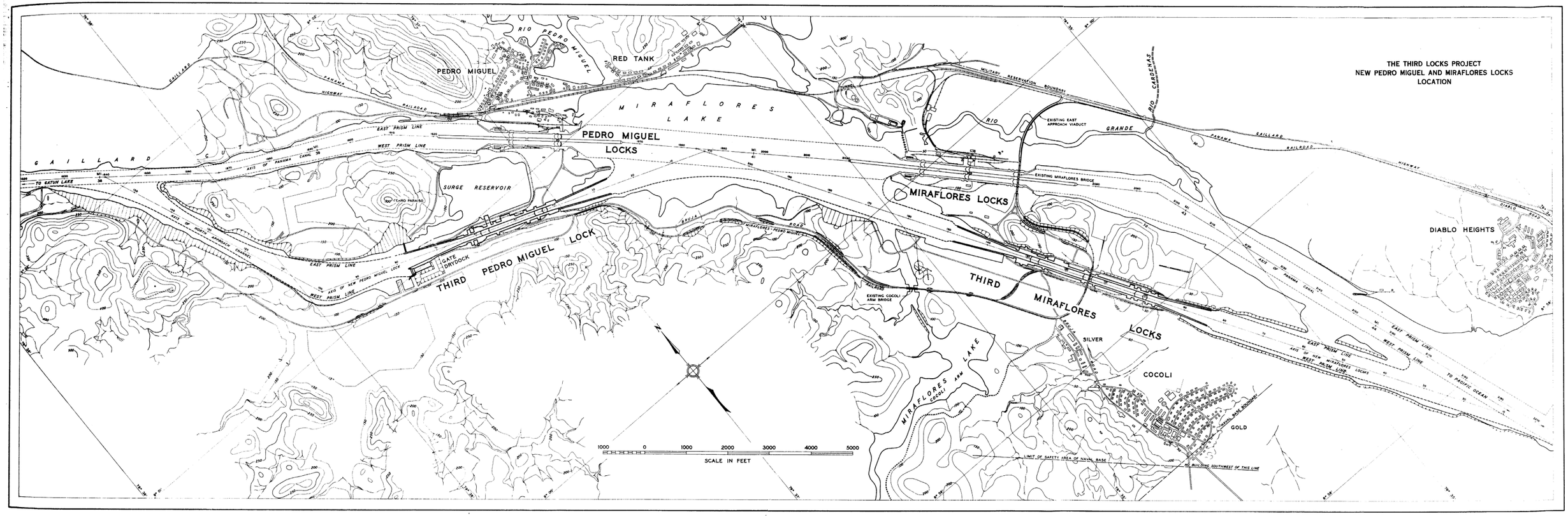


FIGURE 8

chambers and of avoiding contact with the walls, the floor-outlet type of filling system was adopted. The hydraulic characteristics of culverts, ports, valves, intakes, outlets, and approaches were carefully established. Surges in Gaillard Cut were also studied. All designs were verified by means of model tests. A model of one of the existing locks was constructed for comparison with the prototype in order to test the similitude. Comprehensive reports were prepared on flood-control and on water-supply. A meteorological analysis was prepared by the U. S. Weather Bureau.

46. The principal characteristics of the lock hydraulic systems are shown in Figure 9 for the new Gatun Locks. One main culvert in each wall feeds the lateral culverts crossing the floor. Each main culvert is 27 by 15 feet. The maximum discharge is about 13,000 cubic feet per second at a maximum mean velocity of 32 feet per second. The main culverts have multiple-inlet intake ports to reduce the flow effect at the entrance and avoid vortex formation, and also for structural reasons. Two radial valves in each main culvert are located at a reduced section, 20 by 15 feet. Between each gate block there are 18 laterals (10 by 7 feet) without valves. Each gate block has four valved laterals. The lateral spacing is varied, being closer in the upper part of each chamber, to provide a more equal distribution of filling. Each lateral culvert has an area of 68 square feet, and each has eight ports, 7 by 1.5 feet, unequally spaced. Discharge from the lock chambers takes place in the lower approach through outlets similar to but larger than the lateral-culvert outlets.

47. The symmetry of the approach walls combined with the distribution of the outlet laterals will eliminate the irregular cross currents that usually affect adversely the ship movements in the lower approaches.

48. A surge reservoir was designed to prevent excessive surges in Gaillard Cut during the filling of the new Pedro Miguel Lock. By filling the lock about 90 per cent from the surge reservoir and the final 10 per cent from the Cut it is possible to decrease the surges. The filling time is increased from about 8.5 minutes (all filling from the Cut) to about 11.2 minutes.

49. Flood-control studies included the determination of the maximum probable storm for use in design, and comparisons of various flood routings. Water supply was studied in relation to the operation of existing structures and the design and operation of new structures.

Masonry Design

50. The design of the masonry for the locks was a major problem because of the special protective requirements desired. There are three general lock-wall types: Lock-chamber walls, gate-bay walls, and approach walls. All walls, except certain approach walls, are of the

gravity-type, designed to withstand large, unbalanced, lateral loads. Where the elevations of rock permit, approach walls are anchored into the rock for stability. The lock-chamber walls have relatively few openings, and stability requirements constitute the main design problem. The gate-bay walls contain rooms for the operating machinery of miter gates, valves, and numerous appurtenant equipment. Figure 10 shows a typical gate-bay wall section. Stress conditions around the wall openings furnish the main design criterion. The critical design loading on the approach walls is produced by hawser loads and ship impact, and by earth loads where involved.

51. In general, all walls are designed for construction in monoliths 50 feet long. The gate-bay monoliths are a special case and vary in length from about 42 feet to about 68 feet. The height of the approach-wall monoliths varies between 60 to 80 feet, approximately; of the gate-bay monoliths, between 100 and 130 feet, approximately. The height of the lock-chamber monoliths is about 100 feet.

52. The following conditions were investigated for wall design: (1) Construction; (2) Operation; (3) Repair; (4) Earthquake; (5) Earth-at-Rest. Table 2 shows the alternative conditions investigated in each case. Analyses included the stability and stresses from overturning, sliding and shearing at the foundation, and distribution of base pressure. Rigid-frame analyses were used to determine the stresses around openings in the walls. The design stresses adopted for all normal operating conditions are shown in Table 3.

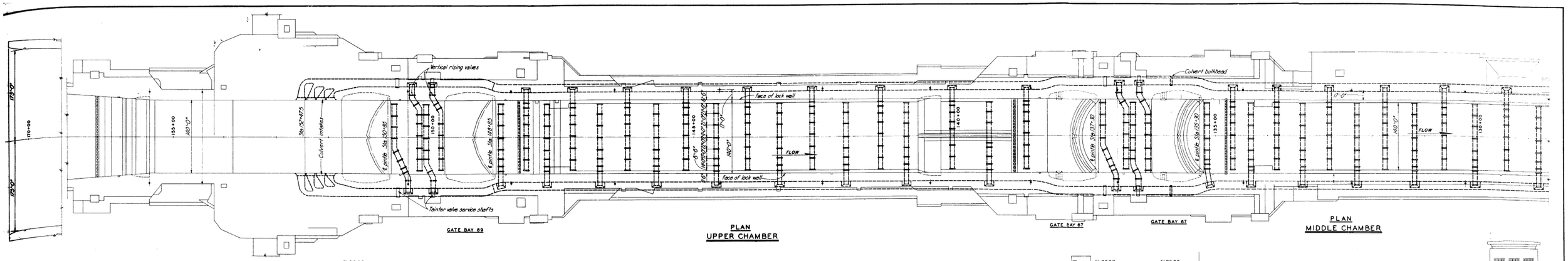
53. Drainage has been provided behind each wall. However, uplift has been assumed from a straight-line gradient between water levels, and the heads have been assumed as effective over 100 per cent of the base.

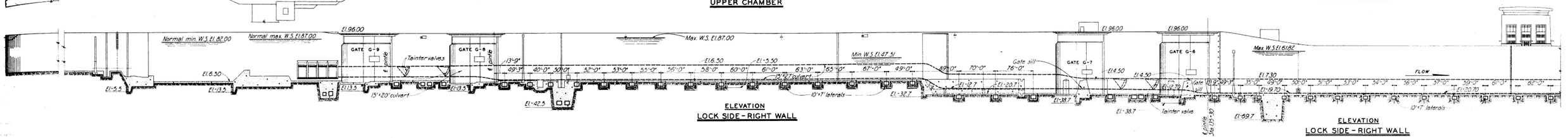
54. Special treatment is provided for unusual foundation conditions such as for the north approach walls at Miraflores which will rest on piers and caissons. Other special conditions, such as small local gouge zones, are expected to be encountered which will require special consideration during construction.

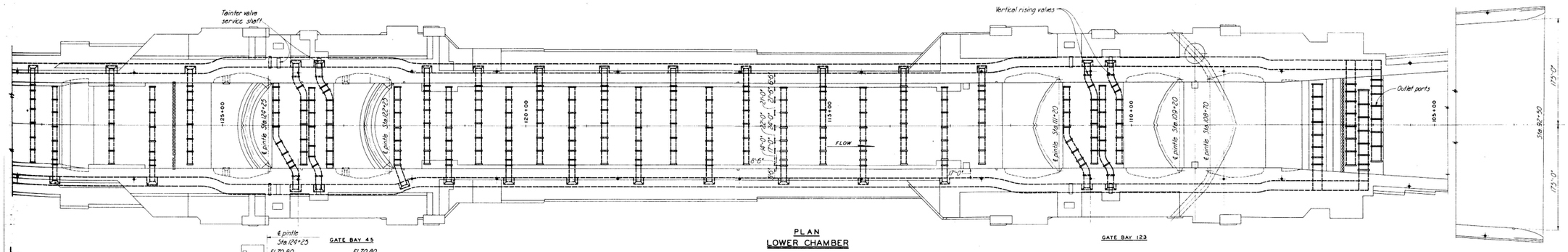
55. The plans provide for the installation of equipment for the measurement of concrete temperatures, joint openings, earth pressures, foundation pressures, uplift pressures, concrete stresses, hydraulic properties of the filling system, and displacement of the completed structures in a limited number of typical locations.

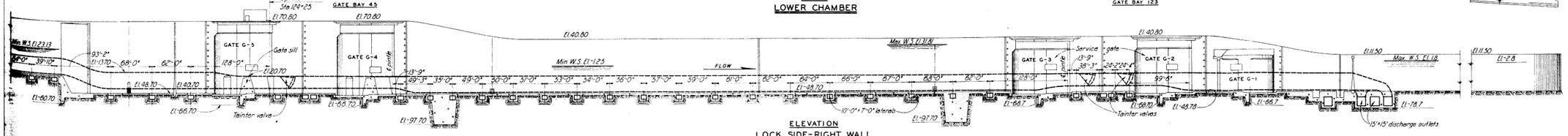
Lock Gates

56. Miter gates were selected for service and unwatering gates after detailed study of several other types. Duplicate service gates are used in all chambers, with pintles 200 feet apart. An emergency









THE THIRD LOCKS PROJECT
DETAILS OF LOCK HYDRAULIC SYSTEM
GATUN

FIGURE 9

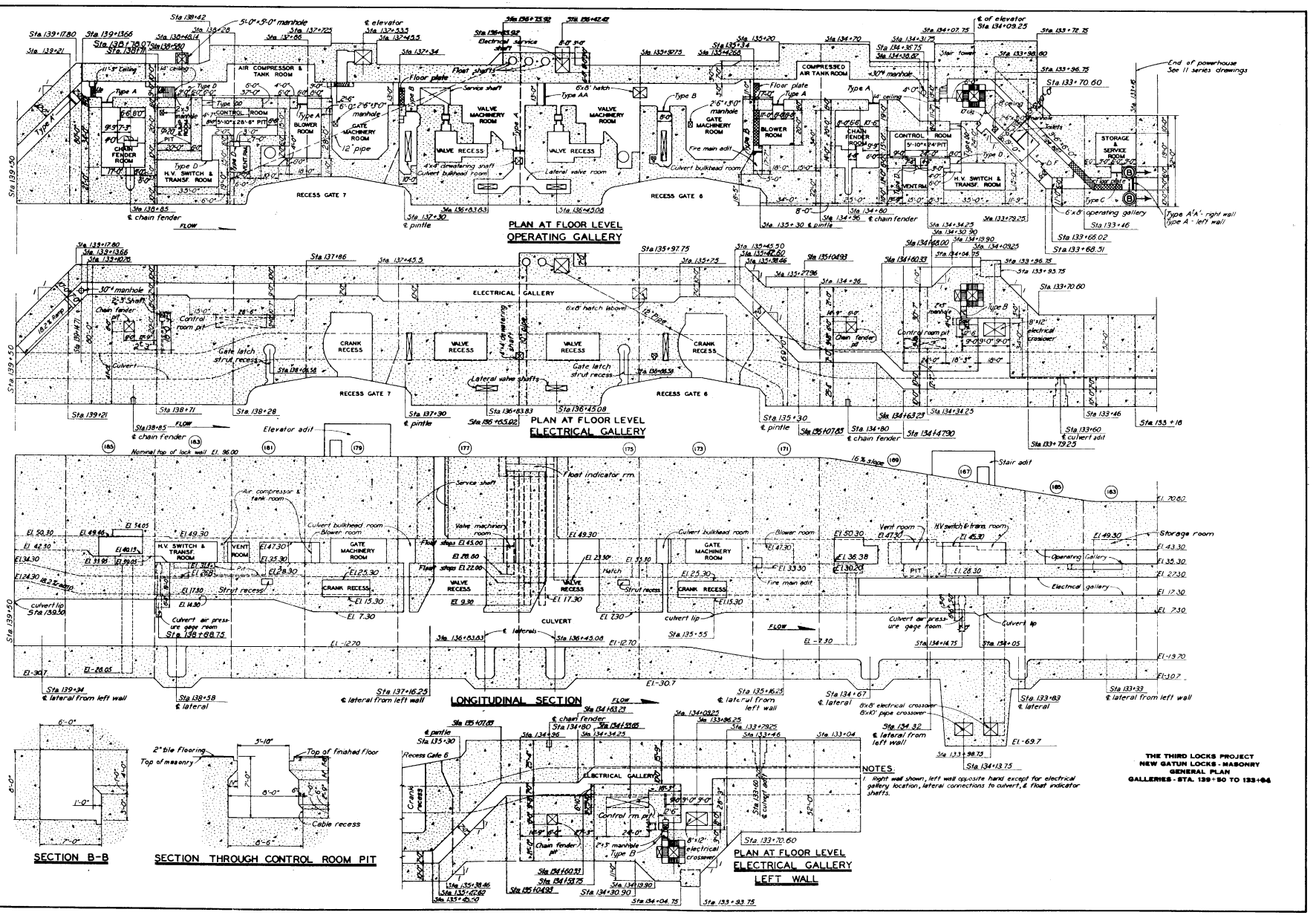

PLAN AT FLOOR LEVEL
OPERATING GALLERY
PLAN AT FLOOR LEVEL
ELECTRICAL GALLERY
LONGITUDINAL SECTION
SECTION B-B
SECTION THROUGH CONTROL ROOM PIT
PLAN AT FLOOR LEVEL
ELECTRICAL GALLERY
LEFT WALL
NOTES.
1. Right wall shown, left wall opposite hand except for electrical gallery location, lateral connections to culvert, & float indicator shafts.
THE THIRD LOCKS PROJECT
NEW GATUN LOCKS - MASONRY
GENERAL PLAN
GALLERIES - STA. 139+50 TO 133+04

FIGURE 10

TABLE 2

LOADING CONDITIONS ASSUMED FOR DESIGN OF LOCK WALLS

Case	Loading Conditions(*)
I.	Construction Condition
	a. Dead weight of structure
	b. Dead weight of structure with dry backfill
II.	Operating Condition
	a. High-water level in chamber with low-water gradient in backfill
	b. Low-water level in chamber with high-water gradient in backfill
III.	Repair Condition
	a. Chamber unwatered with high-water gradient in backfill
IV.	Earthquake Condition(**)
	a. Chamber unwatered with high-water gradient in backfill
	b. High-water level in chamber, low-water gradient in backfill
	c. Low-water level in chamber, high-water gradient in backfill
	d. Dead weight of structure with dry backfill
V.	Earth-at-Rest Condition (used only for computing internal stresses); similar to Case IIb, using earth-at-rest pressure instead of active earth pressure.

(*) Active earth pressure was considered for all loading conditions except as noted in Case V.

(**) In Case IV, earthquake forces are added to the other forces acting on the structure.

THE THIRD LOCKS PROJECT
WORKING STRESSES FOR PLAIN- AND REINFORCED-CONCRETE DESIGN

CONCRETE STRENGTH: f'c

(f'c = 0.75 of average cylinder strength specified)

		Working stress in #/sq.in.
imate strength	f'c =	2700
EXURE: fc		n = 10
Extreme fiber stress in compression	fc = 0.45 f'c	1200
Extreme fiber stress in tension (for plain concrete footings only)	ft = 0.03 f'c	80
EAR: v		
Beams without web reinforcement and without end anchorage of longitudinal steel	Vc = 0.02 f'c	55
Beams without web reinforcement but with end anchorage of longitudinal steel	Vc = 0.03 f'c	80
Beams with properly designed web reinforcement, but without end anchorage of longitudinal steel	Vc = 0.06 f'c	160
Beams with properly designed web reinforcement and with end anchorage of longitudinal steel (when Vc is in excess of 0.06 f'c, web reinforcement should provide for total shear) (see Sect. 817 (e))	Vc = 0.12 f'c	325
Flat slabs at distance 'd' from edge of column capital or dropped panel	Vc = 0.03 f'c	80
Footings with longitudinal bars having no end anchorage	Vc = 0.02 f'c	55
Footings with longitudinal bars having end anchorage	Vc = 0.03 f'c	80
Combined footings and raft foundations designed as beam elements with properly designed web reinforcement and end anchorage	Vc = 0.06 f'c	160
ND: u		
In beams and slabs and one-way footings:		
Plain bars	u = 0.04 f'c	110
Deformed bars	u = 0.05 f'c	135
In multiple-way footings:		
Plain bars	u = 0.03 f'c	80
Deformed bars	u = 0.0375 f'c	100
(Where end anchorage is provided (see Sect. 826) one and one-half times these values in bond may be used, but in no case to exceed 200 lb per sq in. for plain or 250 lb. per sq. in. for deformed bars.)		
ARING: fc		
Full area loaded	fc = 0.25 f'c	675
Load on partial area, fc variable (see Sect. 870), maximum	fc = 0.375 f'c	1010
AL COMPRESSION:		
In pedestals	fc = 0.25 f'c	675
In columns (see Sect. 854–855)		

REINFORCEMENT

NSION IN FLEXURAL MEMBERS, with or without axial loads:	
Structural-grade steel bars	fs = 18,000
Structural-steel shapes	fs = 18,000
Intermediate-grade steel bars, and hard-grade bars (billet steel, rail steel, or axle steel)	fs = 20,000 *
Wire mesh or bars not exceeding one-half in. in diameter when used in one-way solid slabs only	fs = 50 %— —of minimum yield point, but not to exceed 25,000
NSION IN WEB REINFORCEMENT:	
All grades of steel	fs = 16,000
NSION IN COLUMN SPIRALS (see Sect. 854)	
MPRESSION IN COLUMN VERTICALS (see Sect. 854)	
Intermediate-grade steel bars	fs = 16,000
Hard-grade steel bars (billet steel, rail steel, or axle steel)	fs = 20,000
MPRESSION IN COMPOSITE AND COMBINATION COLUMNS (see Sect. 856–857)	
MPRESSIVE REINFORCEMENT IN FLEXURAL MEMBERS (see Sect. 804 c)	

ES:

Table based on "1940 Joint Code—Recommended Practice and Standard Specifications for Concrete and Reinforced Concrete."

References to specification sections refer to the 1940 Joint Code.

f'c used in this table is based on contemplated average cylinder strengths for The Third Locks Project of about 3600 lb. per sq. in. For any case where the specified strength varies from this, f'c and the design factors should be recomputed for the new average strength specified.

Lower stresses shall be used where the character of the structure so warrants.

TABLE 3

dam is placed above the upper service gates and space for another emergency dam is available. Unwatering gates are provided at the downstream end of each lock. Outside caisson seats are used at both ends of the locks, and guard chains are placed across the upper and lower approaches and near each set of duplicate gates in the upper chamber.

57. All service gates are designed for the same maximum head and are interchangeable. All gates are of structural-grade steel, all-welded, and are designed for normal operation under a maximum stress of 18,000 pounds per square inch in tension or bending, with 25 per cent increase when the chambers are unwatered. Allowances were made for the skin plates on both sides to carry stress. The 84.5-foot service gates weigh about 768 tons per leaf. Figure 11 shows the general assembly of the service gates.

58. Each gate is designed as a 3-hinged arch on a span of 154 feet 5-3/4 inches, with a rise of one-fourth of the span. The upstream face of each gate leaf consists of three vertical surfaces. At the middle the width of the leaf is 9 feet 9 inches. The width is 3 feet 5 inches at the bearing castings. The upstream skin plate is watertight and effects the desired closure. The downstream skin plate is vented, except for a section covering the buoyancy chamber. The interiors of the leaves are divided into horizontal chambers. One watertight chamber contains the machinery and the others are used to vary the buoyancy of the gate for setting and operation. Buoyancy chambers may be flooded when desired by means of 18-inch, motor-operated valves. Each leaf is supported on a pintle and the upper corner is hinged to the wall by a gudgeon-pin, link, and anchorage system.

59. The leaves are designed for fabrication in the United States, towing in a flat position to the Canal Zone, and righting in the lock chambers. The righting procedure varies depending on the location of the gate and the sill heights. The leaves may be set with the aid of pontoons or with a large floating crane. Quoins and bearing plates can be set by template, and the pintles are fixed into the gates to facilitate overhaul by removal of the gates without laying-up the locks.

60. Because of the location of the gate operating machine, a crank-and-strut type of mechanism was devised. Two 75-horsepower motors open the gates in 2.25 minutes. The motors are connected through hydraulic couplings so that one motor can operate the gate at slower speed if necessary without disconnecting the other one. Latching machines are provided to hold the leaves against abnormal forces that may tend to pull them from the recessed position. A walkway on each service gate permits crossing between lock walls. A roadway 9 feet 9 inches wide, designed for an H-10 loading crosses each pair of unwatering gates.

Lock Valves

61. Reversed-tainter valves were adopted to control the flow through the main culverts into or out of the lock chambers. These valves are designed to operate throughout a wide range of heads in still or flowing water. Two valves are used at each location so that one may be available when the other is inoperable. The valves are subjected to a maximum operating head of 65.2 feet, but for short periods during unwatering a maximum static head of 103.4 feet is possible. All-welded construction was used in the valves. The tainter valves are designed for load equivalent to 200 feet of head to resist shock. A basic stress of 18,000 pounds per square inch was used for structural steel. Each complete valve assembly weighs about 99 tons, with the heaviest detachable part weighing about 27 tons. Figure 12 shows the general assembly of culvert valves.

62. Each valve consists of a circular-segment leaf, 15 feet wide with a 24-foot arc (15- by 20-foot culvert section), and four radial strut arms, 25 feet long, that connect the leaf to a hollow trunnion shaft. The shaft extends the full width of the culvert and its ends turn in bearing blocks supported on cast-steel hangers. Seals are provided at the top, the bottom, and the sides of the valve.

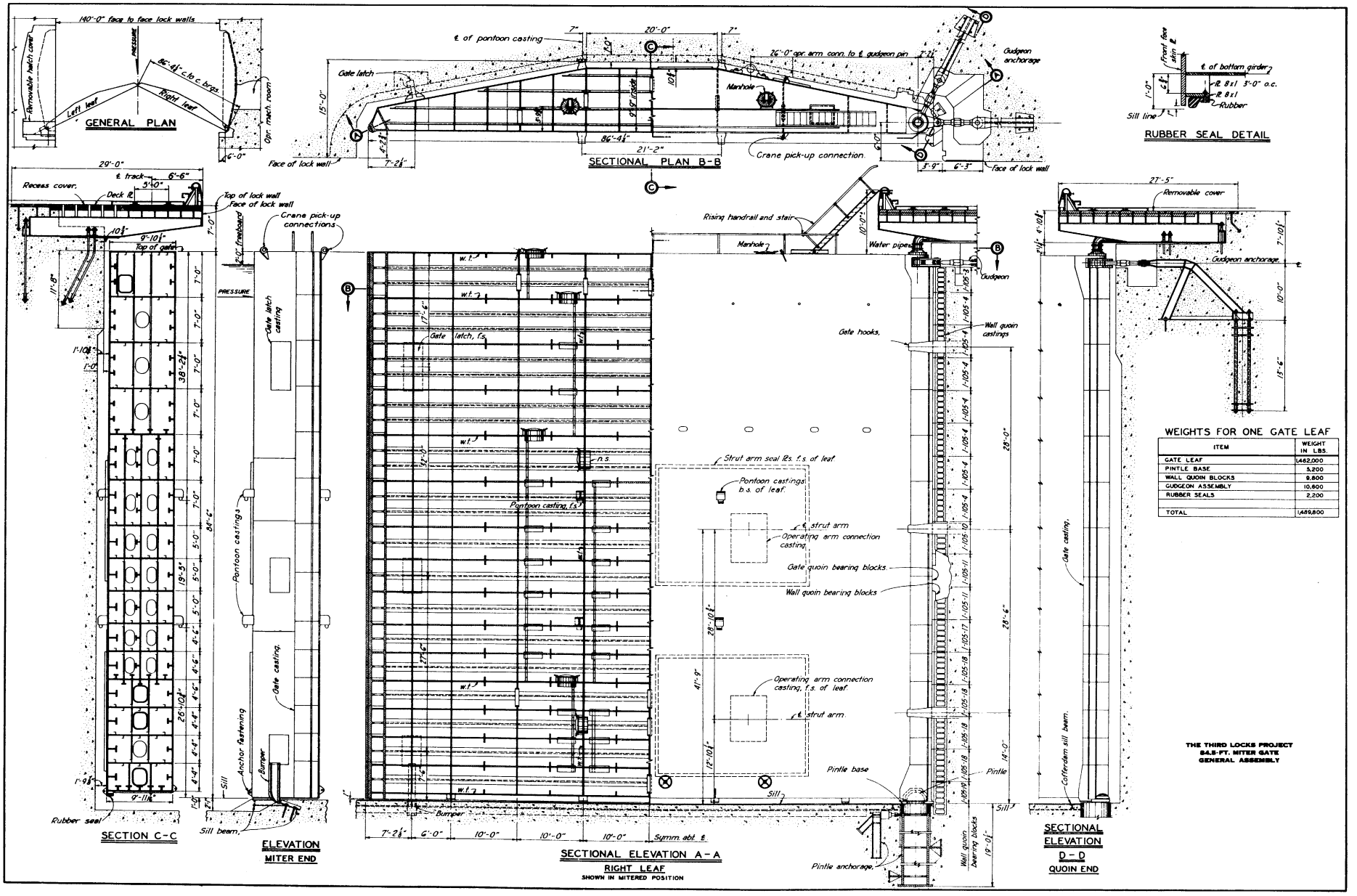
63. The main valves are operated by machinery of the crank-and-strut type. The machinery is driven by a 30-horsepower motor that permits 3-minute operation of the valve. Figure 13 shows the general arrangement of the valve-operating machinery.

64. Flow through the four lateral culverts that serve the space between gates in each miter-gate block is controlled by valves of the sluice-gate type that slide vertically in cast-iron frames. These valves will not be operated under head, and serve only for adjusting or sealing the flow as required. All lateral-culvert valves are designed to withstand a shock load equivalent to a 300-foot head. A 15-horsepower motor permits 3-minute operation of the lateral valves.

Emergency Dams

65. Movable dams to prevent the loss of water from Gatun or Miraflores Lakes in case the miter gates in the upper chambers are inoperable, or in case of imminent damage, have been included in the design. One dam is to be placed at each lock, but space has been provided for later installation of another dam, not necessarily of the same type, if desired.

66. The dams are installed in the upper approaches of the locks, 236 feet upstream from the pintles of the uppermost miter gates. A dam consists of two armored-steel rolling structures of isosceles-triangle cross section which meet at the center of the lock. The dams at Gatun and Pedro Miguel are 58 feet high and have a base width of 73.5 feet.

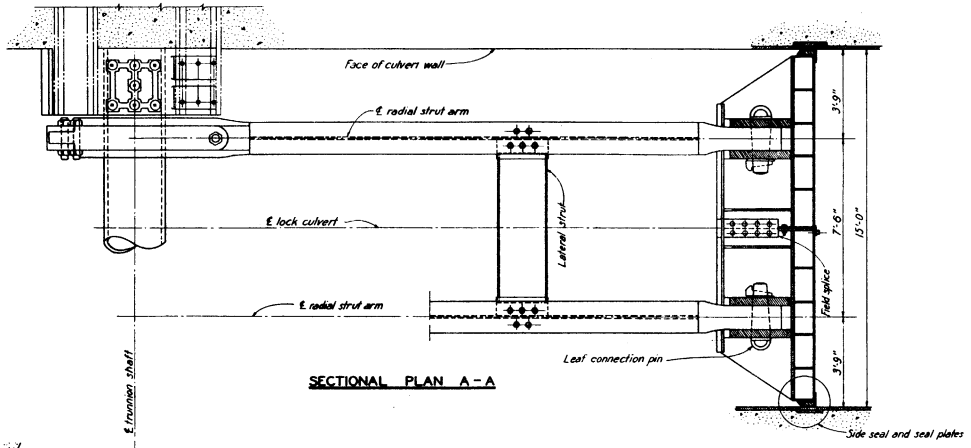


WEIGHTS FOR ONE GATE LEAF

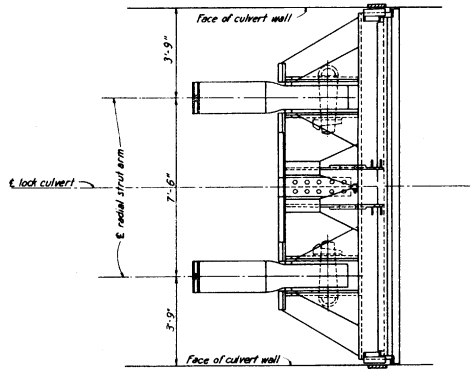
ITEM	WEIGHT IN LBS.
GATE LEAF	1,462,000
PINTLE BASE	5,200
WALL QUOIN BLOCKS	8,800
GUDGEON ASSEMBLY	10,600
RUBBER SEALS	2,200
TOTAL	1,489,800

THE THIRD LOCKS PROJECT
84.5-FT. MITER GATE
GENERAL ASSEMBLY

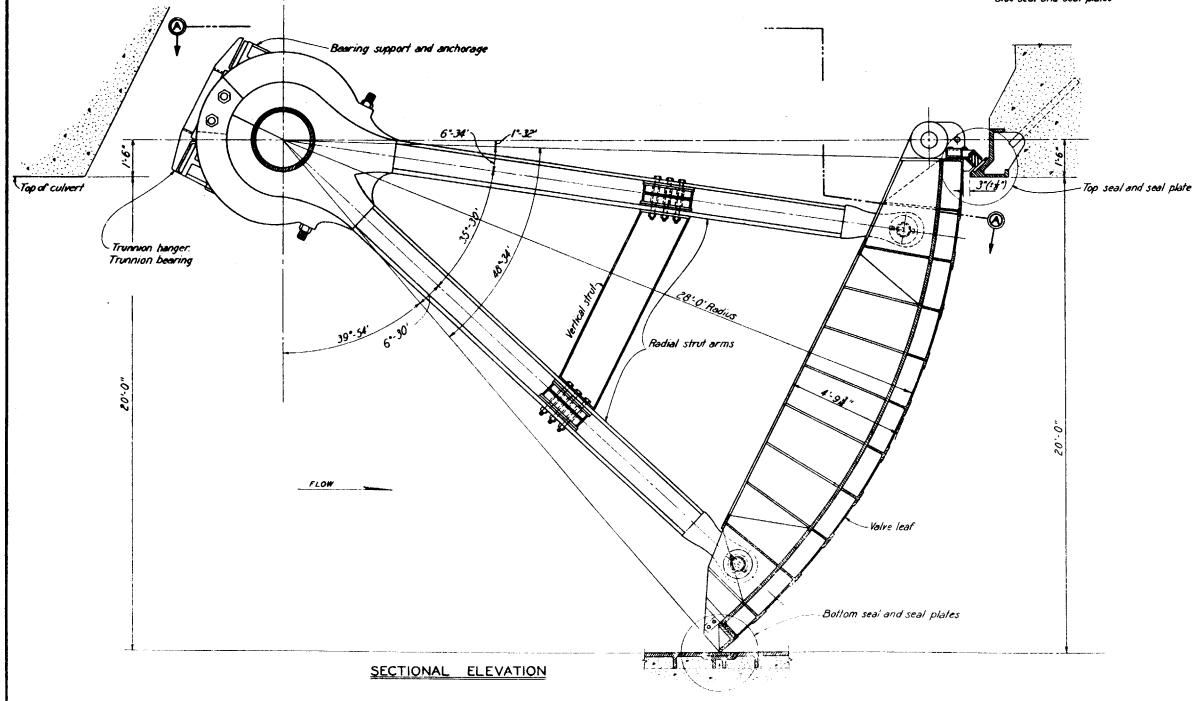
FIGURE 11



SECTIONAL PLAN A-A



PART PLAN



SECTIONAL ELEVATION

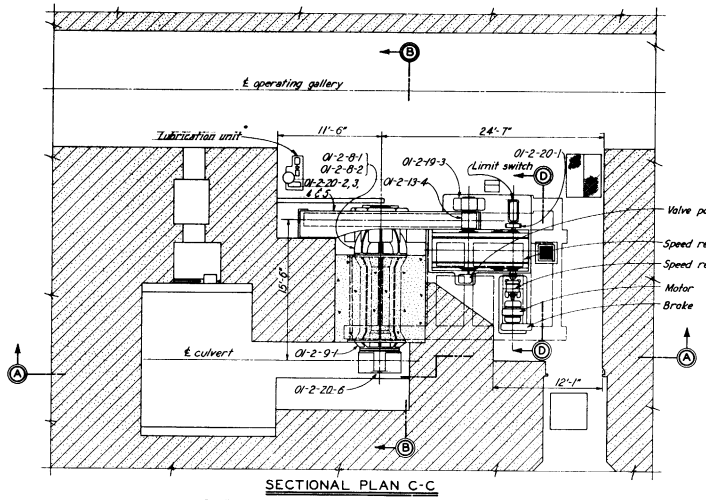
NOTE:

1 The weights of the various unit assemblies for one valve assembly are as follows:

Valve leaf	54,400 lbs.
Complete strut assembly	86,100 lbs.
4 leaf connection pins	1,585 lbs.
Trunnion shaft	9,710 lbs
Hangars, blocks and bearings	41,120 lbs.
Seals	4,410 lbs.

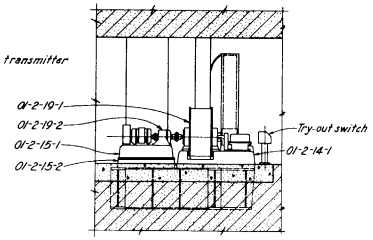
THE THIRD LOCKS PROJECT
LOCK CULVERT VALVES
INSTALLATION
GENERAL ASSEMBLY

FIGURE 12

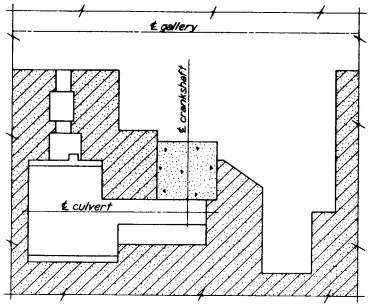


SECTIONAL PLAN C-C

RIGHT WALL MACHINE ROOM AT UPSTREAM VALVE AS SHOWN
LEFT WALL MACHINE ROOM AT UPSTREAM VALVE OPPOSITE HAND

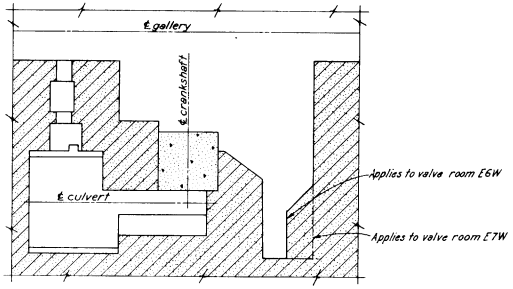


SECTIONAL ELEVATION D-D



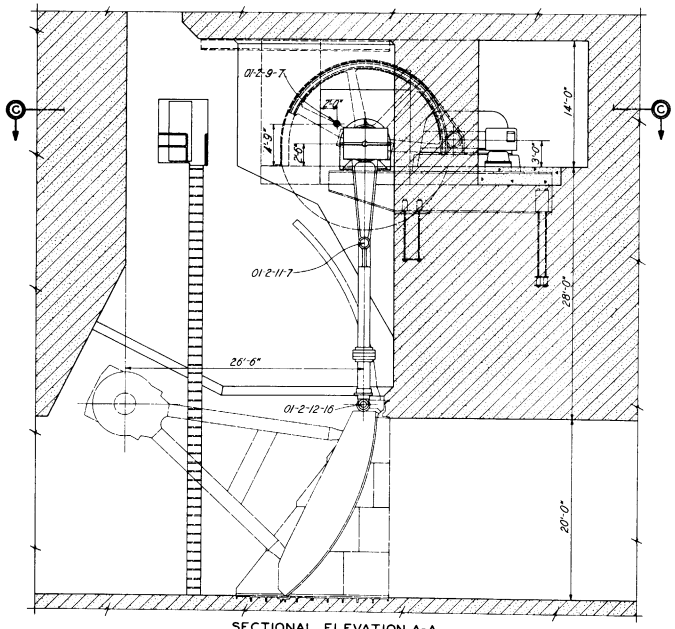
MACHINE ROOM AT DOWNSTREAM VALVE

RIGHT WALL AS SHOWN
LEFT WALL OPPOSITE HAND

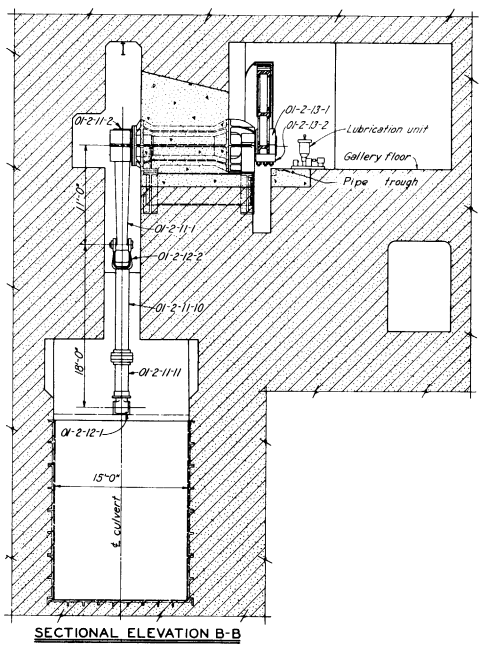


MACHINE ROOMS AT PEDRO MIGUEL SURGE RESERVOIR CULVERT INTAKE

E6W & E7W AS SHOWN
E6E & E7E OPP HAND



SECTIONAL ELEVATION A-A



SECTIONAL ELEVATION B-B

THE THIRD LOCKS PROJECT
LOCK CULVERT VALVE OPERATING MACHINERY
GENERAL ARRANGEMENT

FIGURE 13

The dam at Miraflores is 49 feet high and has a base width of 68.5 feet. Each leaf or part of the dam is recessed in the lock wall when the dam is open. The leaves are about 76 feet long, are of all-welded construction, have inner and outer skin plates, and are divided into compartments by transverse bulkheads. The outer skin plates are of 10-inch low alloy steel. Each of the larger leaves weighs 4014 tons. The loads are carried by ring-spring mounted trucks traveling on extremely heavy steel tracks. Figure 14 shows the general assembly of the emergency dams.

67. The dams are designed to operate by two different methods: (1) Normal operation, in still water; and (2) Hydraulic operation, when there is a difference in hydrostatic head between the two ends of a leaf. Normal operation will be performed by a double-acting hydraulic jack with a piston rod supported by a carriage near the end connected to the leaf. The machine is operated with oil supplied by three centrifugal pumps that can be operated in series or in parallel giving pressures of 624 and 208 pounds per square inch, respectively. Hydraulic operation will start automatically about 6 seconds after free flow begins past the dam. Water for the operation is supplied by a culvert that connects with the approach channel.

Chain Fenders

68. The miter gates most vulnerable to accidents and those whose destruction would be disastrous will be protected by chain fenders. The arrangement, uniform at all locks, provides for a fender at the lower approaches, fenders at both ends of the upper chambers, and a fender at the upper approaches. Figure 15 shows the general arrangement of the fenders, which are designed to stop a 120,000-ton vessel moving at about 3.5 miles per hour.

69. A forged alloy-steel chain with a nominal bar diameter of 3 inches and a breaking strength of 1,050,000 pounds was selected. A working load of 484,000 pounds was used for design.

70. The braking machine for the fenders consists of 6 rotary-gear pumps connected to a central wildcat. The pumps are designed to maintain a pressure of 1200 pounds per square inch. A hydropneumatic accumulator is used to maintain uniform torque input to the pump at low operating speeds where the torque input would tend to vary.

71. The machine is actuated for normal operation by a 100-horsepower motor. Figure 16 shows the general arrangement of the chain-fender machine.

Towing System

72. Vessels will be towed through the locks by 65-ton, rigid-frame,

straight-electric locomotives. Service speeds are available for towing at from 1 to 3 miles per hour with a 35,000-pound towline pull on a grade of 16 per cent. Without a tow, on level track, speeds up to 10 miles per hour are specified.

73. Connection to the vessel will be by means of 1-inch wire rope controlled by a drum holding 440 feet of rope, single lay. Normal rewinding speed of the windlass is up to 15 feet per minute under full tension.

74. The locomotives will operate with direct current from an underground distribution system. The alternating current of the power system will be converted to direct current by means of mercury-arc rectifiers in converter stations at each lock site. Power is transmitted through collector rails to collector plows on the locomotive.

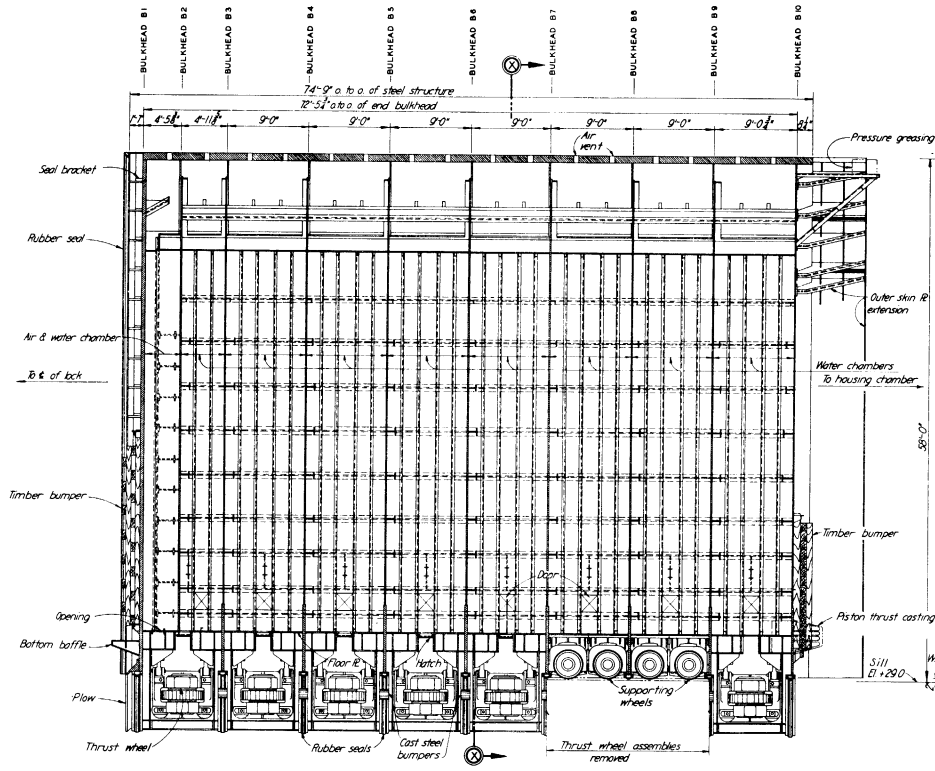
75. A rack pinion on each axle will propel the locomotive. Running gear consists of two axle assemblies spring-mounted to the frame through anti-friction bearings. The middle part of each axle is machined to carry a quill for the driving pinion. The Abt system of rack-and-pinion drive is used.

76. Towing tracks are parallel to the lock walls and extend to within 50 feet of the ends of the walls. Passing tracks at Miraflores and Gatun are connected by turnouts to the towing tracks. No passing tracks are needed at Pedro Miguel. The trackage, except that on the east wall at Pedro Miguel, is connected to the Panama Railroad tracks.

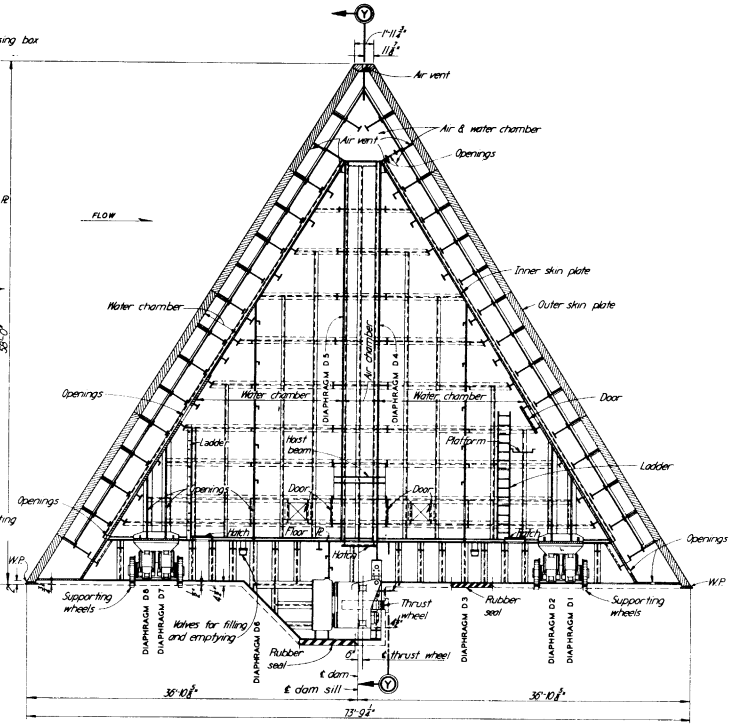
Locks Power Supply

77. The power required for the normal operations of the locks will be obtained from the existing Panama Canal 25-cycle electrical system. Frequency changers located within the lock walls will convert this power to 60-cycle, 11.5-kv for distribution within the structures. The connection for Gatun Locks will be made by means of a 7500-kva, 44-kv wye/11.5-kv delta, 3-phase, 25-cycle, outdoor-type transformer located within the lock wall. The Pacific Locks connections will be made from a new 44-kv loop to be installed along the west bank from Summit to Balboa. Transformers will be rated 7500 kva and 3750 kva for Miraflores and Pedro Miguel, respectively.

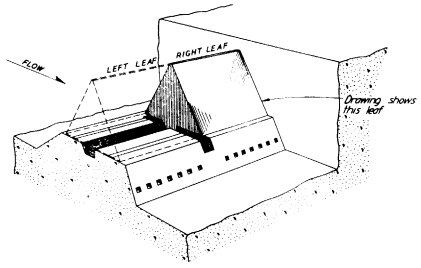
78. Emergency stand-by power is furnished by diesel-electric generating sets to be located at each separate lock. The plant at Gatun consists of three 2500-kw, 11.5-kv, 60-cycle generating units. Each plant for the Pacific Locks has two similar units. These plants are fully automatic with remote starting and operating control located in the central control stations. The engines are of the solid-injection type, 2-cycle, 240-rpm., air-starting, with enclosed water circulation. Large internal explosion-proof tanks are provided for the supply of fuel and lubrication oils.



SECTIONAL ELEVATION AT Y-Y



CROSS SECTION AT X-X



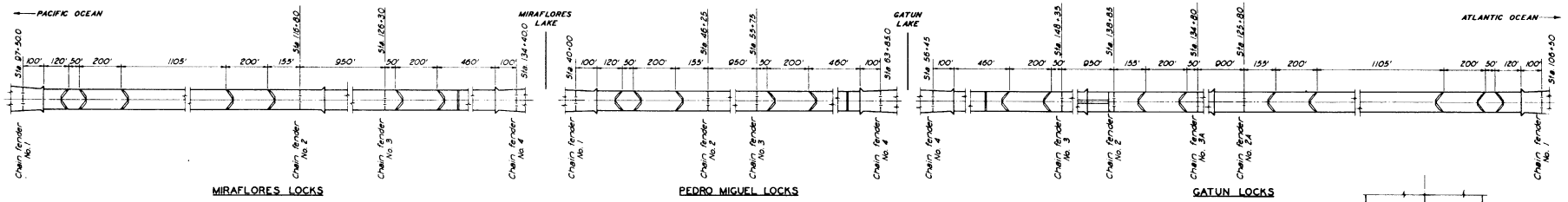
LOCATION SKETCH

NOTES:

1. All drawings: except as noted, are for the right (west) leaf of the dam, as shown on the location sketch, and for the housing chamber and appurtenances for this leaf. The left (east) leaf is similar but opposite hand.
2. Unless otherwise noted, all quantities listed on the drawings are for material shown on the drawing bearing the tabulation and are total quantities required for the complete installation of the two leaves.
3. All piece mark numbers shown on detail drawings shall be prefixed by 57. Example, mark 63-4-11-1 would become 5763-4-11-1.

THE THIRD LOCKS PROJECT
EMERGENCY DAM
GENERAL ASSEMBLY PLAN

FIGURE 14

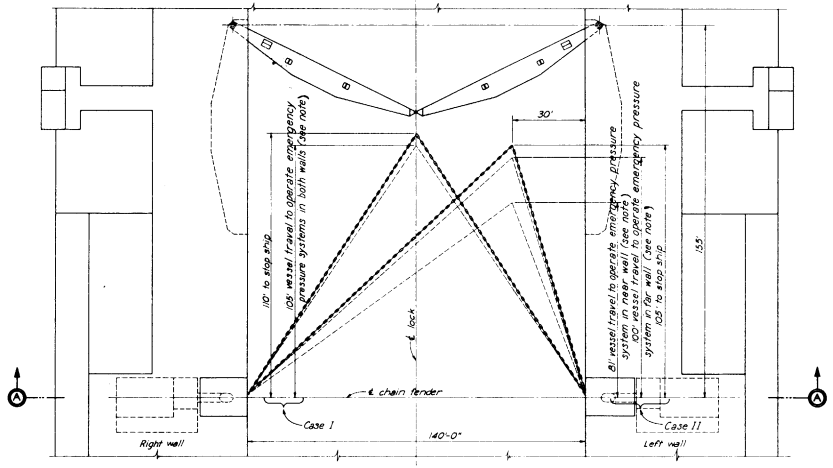


MIRAFLORES LOCKS

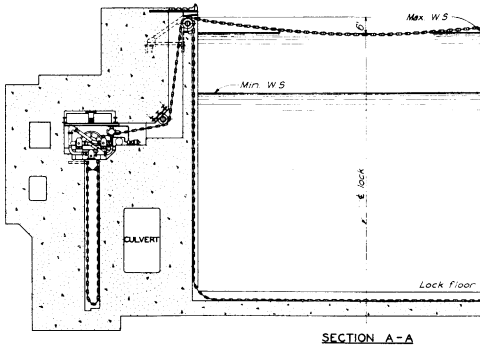
PEDRO MIGUEL LOCKS

GATUN LOCKS

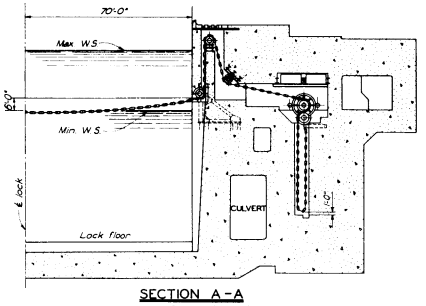
LOCATION PLAN



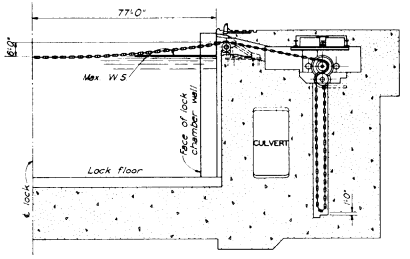
PLAN



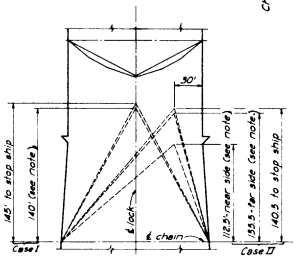
SECTION A-A
CHAIN FENDER NO. 2



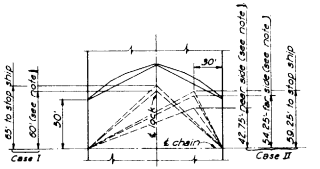
SECTION A-A
CHAIN FENDER NO. 3



SECTION A-A
CHAIN FENDER NO. 1



PLAN CHAIN FENDERS NOS. 1 & 4



PLAN CHAIN FENDERS NOS. 3 & 3A

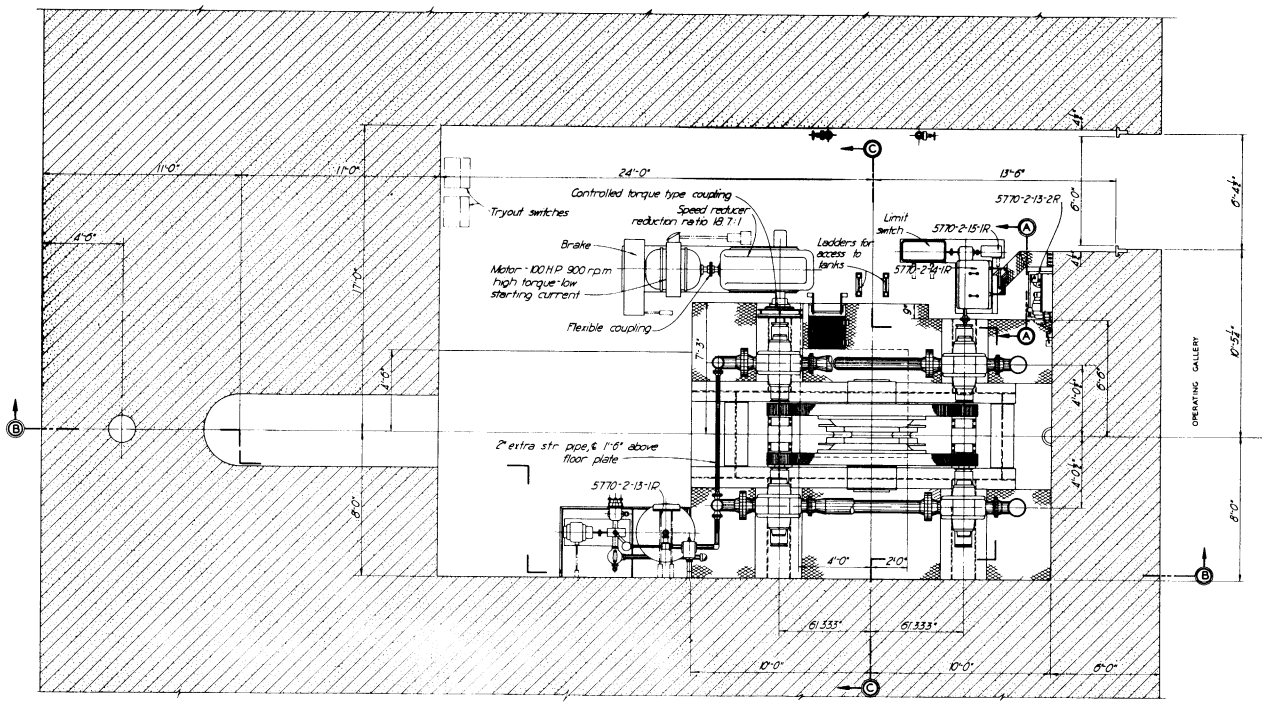
NOTES:

1. Under the operating conditions assumed in Case I, equal lengths of chain are payed out from each fender machine and when the vessel reaches the position shown, the first phase of the emergency operation is completed and the emergency pressure systems in both walls start functioning to oppose the rotation of the pumps.

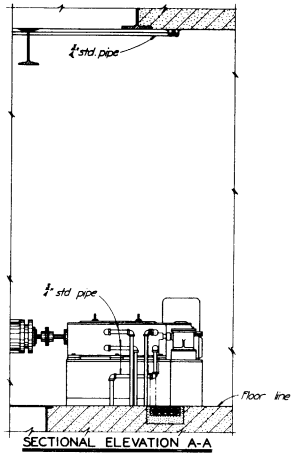
2. (a) Under the operating conditions assumed in case II the chain is payed out more rapidly from the machine in the wall nearest the vessel, consequently the emergency pressure system in the near wall will function first and at the vessel position shown for the respective fender.
(b) Operation of the emergency pressure system in the far side wall at the vessel position shown completes the first phase of the emergency operation in Case II.

THE THIRD LOCKS PROJECT
CHAIN FENDER
GENERAL ARRANGEMENT

FIGURE 15



PLAN



SECTIONAL ELEVATION A-A

NOTE:

1. Plan as shown is for right hand machine assembly.
2. Section shown from face of lockwall to machinery room is typical of chain fenders No. 3 only. Section through machinery room is typical of chain fenders No. 2, 3, and 4.

THE THIRD LOCKS PROJECT
CHAIN FENDER
ASSEMBLY PLAN
CHAIN FENDERS 2, 3, AND 4

FIGURE 16

79. The frequency changers will be located with the diesel-electric units. They are designed to supply energy back to the Panama Canal system from the diesel units as well as to supply the normal operation from the 25-cycle system. Like the diesel units, they are fully automatic with remote control from the central control stations. They are rated at 7500 kva for Gatun and Miraflores, and at 3750 kva for Pedro Miguel. The 60-cycle supply of the two Pacific units will be tied together for parallel operation. Starting is accomplished by 60-cycle starting motors.

80. As noted above, the equipment in the emergency power plants is automatic. This control provides automatic starting of all auxiliaries in the proper sequence, matching speed with other operating units and synchronizing for parallel operation. Automatic synchronizing with both 25- and 60-cycle systems is provided on the frequency changers. The units are safeguarded during operation by devices for all critical operations.

81. The equipment of the emergency power plants has been installed in temporary settings to provide 60-cycle power for construction operations and to augment the existing Panama Canal system in case of water shortages for the existing hydroelectric facilities. The Pedro Miguel and Miraflores plants have been combined in one building for this purpose.

Locks Electrical System

82. Sixty-cycle, 3-phase, 440-volt equipment was selected for all power operations of the locks, except (1) sprinkler (fire) pumps which operate at 11.5 kv, (2) unwatering pumps which operate at 2.2 kv, and (3) the towing locomotives which operate with 250-volt direct current. The connected loads are approximately 31,000, 15,000, and 22,000 horsepower, at Gatun, Pedro Miguel, and Miraflores, respectively. The probable demands under normal operations will not exceed the capacity of the frequency changers. The emergency power plants will be available to supplement this capacity for extraordinary emergency demands.

83. The 60-cycle power is distributed from the frequency changers or from the diesel-electric stand-by units at 11.5 kv to transformers located in the gate-bay areas on both walls and to the mercury-arc rectifiers located in each wall at both ends of Gatun and Miraflores Locks and at the lower end of Pedro Miguel Lock. Except for the unwatering pumps, station service, and the rectifier supply, all power transformers are 11,500/480-v, 450-kva, 3-phase. The unwatering pump transformer is 11,500/2,400-v, 450-kva, 3-phase; the station service transformer is 11,500/480-v, 600-kva, 3-phase; and the rectifiers are rated 1000-kw, 275-v continuously, 1500-kw for two hours, and 3000-kw for one minute. Lighting transformers are 11,500/120-208-v, 100-kva, 3-phase. Duplicate primary circuits encircle the structure. These circuits are manually sectionalized. Automatic transfers for current from either primary circuit

are provided on the power rectifiers. The two power and two lighting transformers at each gate area are divided between the two primary circuits, and automatic load transfers are provided on the secondary circuits in case of failure of one circuit or transformer.

84. All operating equipment is controlled from either of two central control stations or at stations adjacent to the equipment. The remote-control circuits carry 120-volt direct current. Local station control is through the alternating current supply.

85. Control bench boards designed as a replica of the locks in plan are located in the top floor of the main central control station and in the emergency central control station located in the wall beneath the control station building. Indications of the operations are provided by miniature miter gates, valves, chains, and bridges synchronized with the prototypes; differential water-level indicators; and colored lights. One side of the bench contains the control for all normal operations and the other side contains the control for emergency equipment. A separate master control board controls the power supply, including the remote starting, and the operation of the emergency power plant units.

86. Limit switches are provided in the control circuits for stopping the machines and for interlocking where required.

87. The control equipment for the bridges at Gatun and Miraflores has been selected to permit their remote operation from the locks central control station, if desired in the future. The desirability of such operation depends upon the volume and nature of traffic which may develop on the bridges.

88. Telephone communication is provided through a PABX system from all operating areas and numerous points above the wall. Direct lines connect the lockmasters' jack-stations with the operator in the central control station.

89. Floodlighting has been provided for night operations. Smaller lights serve the area for pedestrian travel and augment the floodlights in certain locations. All exterior lighting is controlled from the central control stations and interior lighting is controlled locally.

Bridges

90. There are three steel bridges in the project. One of these bridges crosses the existing Miraflores Locks and has been completed. The others will cross the new locks at Gatun and Miraflores. The bridge over the existing Miraflores Locks consists of an east approach of twenty-seven 62-foot steel girder spans supported on steel trestle bents and two independent bobtail swing spans, 184 and 92 feet long, resting on concrete

piers. The bridges over the new locks are also of the swing type. The Miraflores Bridge, because of its location, has two symmetrical arms, each 218 feet long, to permit coordination with lock operation by swinging 360 degrees in either direction. The Gatun Bridge is a bobtail with arms of 218 feet and 109 feet.

91. The trusses of all bridges are of Warren type framing with verticals, and are of typical riveted construction. The bridges have a vertical clearance of 20 feet and carry a roadway 22 feet wide. Provision is made also for railway and pedestrian traffic. They are designed for H-20 highway loading and E-45 railroad loading, modified for special highway and railway ordnance loads. In general, the allowable stresses conform to A.R.E.A. standards. Operating machinery is electrically controlled by an operator at each bridge. The machinery for the bridge over the existing Miraflores Locks is located on the spans. On the other bridges it is located on the piers.

92. Concrete bridges were designed for use over the Cocoli River and over the drainage canal in the Atlantic Area. The design loadings conform to those used for the other bridges.

93. Studies were made of facilities to permit the passage of barges and other equipment through or under the existing bridge over the Chagres River at Gamboa. Detailed studies were developed for: (1) The alteration of a span of the bridge to a vertical-lift span; (2) Conversion of a fixed span to a swing span; and (3) Use of flooding and dewatering barges. Construction plans are available for the last two methods.

Miscellaneous Structures and Equipment

94. Operations of the locks are controlled normally at each lock from a central control station. The control stations at Gatun and Miraflores are identical. They are 5-story reinforced-concrete buildings, 95 by 55 feet in plan. The first floor contains a lobby, lockers, toilets, and rest rooms. The second floor contains offices. A large observation room is provided on the third floor. The fourth floor contains the cable room, and the fifth floor, the control room. Communication between floors is by means of a stairway and an elevator. The Pedro Miguel control station is 74 feet 7 inches by 49 feet 3 inches in plan. Its construction and arrangement are similar to those of the larger stations, but it has only four stories since the single-lift does not require as much height for vision. No observation floor is provided. The monumental type of architectural treatment for the central control stations was adopted as a symbol of the importance and magnitude of the project, which would be visited by large numbers of international transients.

95. At each lock, shops and service buildings are provided for routine maintenance and repair of operating equipment. The shop buildings, 184 by

84 feet in plan at Gatun and Miraflores, are of the industrial type and have three bays. The floor space is divided into separate shops, a tool room, and an erecting area. The Pedro Miguel shop is smaller.

96. Two locomotive service buildings are provided at each lock. The buildings are of reinforced-concrete construction, 77 feet by 33 feet 8 inches in plan, and contain the necessary facilities for maintenance of the towing locomotives.

97. Bulkheads are used at all critical locations in the operating galleries to protect machinery and equipment from water and gas. Basic types of doors and bulkheads were designed for the conditions peculiar to the various locations. The bulkheads and doors are designed to protect against (1) a breached wall between a lock chamber and a gallery, (2) a breached wall between a lock chamber and a machinery or equipment room, and (3) a breached bulkhead between a main culvert and a machinery room. Depending on the type of service for which the bulkheads are used, their control is manual, by push-button, automatic by power failure, or automatic by floats actuated by rising water in selected locations. Some of the bulkheads have multiple types of control. In general, the bulkheads are of the swinging type for sealing in one direction. One type of bulkhead consists of a sliding, watertight, single-seat door, designed to withstand gas pressure or water pressure from either direction. Design loadings were assumed at twice the hydrostatic head.

98. A compressed-air system is used for (1) expelling water from the buoyancy chambers of the miter gates, (2) maintaining air pockets in the main culverts, (3) powering pneumatic equipment and (4) servicing the Gatun Dry Dock. The compressors can furnish 425 cubic feet per minute of free air at 200 pounds per square inch in two-stage operation, or 600 cubic feet per minute at 20 pounds per square inch in single-stage operation.

99. Elevators are provided between the operating galleries and (1) the top of lock walls, (2) the electrical crossovers under the locks, (3) the emergency power plant and (4) the control-room floor of the central control station. The elevators will permit rapid movement of personnel and will facilitate transportation of machinery and equipment required for maintenance operations.

100. A forced ventilation system provides an adequate supply of air to operating personnel and prevents the stagnation and stratification of gases that may infiltrate into the galleries and crossovers. The system furnishes 10 complete changes per hour to machinery rooms and maintains maximum air velocities of 2000 feet per minute in the main ducts and 1000 feet per minute in the branch ducts. Rooms containing electrical control and switching equipment that are vital to the operation of the locks are air conditioned by filtration and dehydration for reduction in maintenance and for decontamination of gas from the air supply.

101. For protection of the miter gates, provision has been made for the future installation of a net to span the lock chambers and extend from high-water level to the chamber floors. The tentative design provides for a type of net now in common use.

102. Sump-pump installations are required to remove accumulated water from approach galleries, chain-fender pits, net rooms and storage rooms in the approach walls, elevator pits, electrical shafts, basements of emergency power plants, and shafts for permanent installations of unwatering pumps. Vertical centrifugal pumps, driven by electric motors, are used at all locations.

103. A sump-pump installation is required to pump sewage at Miraflores Locks. Sewage at Gatun and Pedro Miguel is disposed of by gravity flow.

104. Crossover mains carry the fresh-water supply to all locks. Connections in the galleries are provided for drinking fountains, cooling equipment, toilets, and hoses for general maintenance.

105. Separate systems are installed for unwatering spaces that are normally flooded, such as lock chambers, culverts, valve chambers, miter-gate crank recesses, emergency-dam housing chambers and culverts, and the miter-gate dry dock at Pedro Miguel.

106. The unwatering installation at each lock consists of two vertical-shaft, 36-inch, centrifugal pumps with a capacity of 38,000 gallons per minute against a 34.5-foot head and driven by 450-horsepower motors. Unwatering requires 26.6 hours at Miraflores, 25.3 hours at Gatun, and 18.7 hours at Pedro Miguel. The water trapped in back of the sills at Miraflores and Gatun may be removed by two portable pumps in about 11.5 hours at Miraflores and about 12 hours for either the upper or the middle chamber at Gatun.

107. The valve chambers are unwatered by a 5-inch portable centrifugal pump with a capacity of 2500 gallons per minute at a 75-foot head. The miter-gate crank recesses are unwatered by a portable 4-inch centrifugal pump with a capacity of 400 gallons per minute at a 75-foot head. The emergency-dam housing and its connecting culverts are unwatered by a deep-well turbine sump pump rated at 2500 gallons per minute against a 75-foot head. The Pedro Miguel Dry Dock is unwatered in 16 hours, after draining to a depth of 23 feet, by a mix-flow turbine pump rated at 10,000 gallons per minute against a 75-foot head.

108. The service gates are protected against fire by a sprinkler system that provides 4900 gallons per minute per leaf, through four headers on each upstream face and six headers on each downstream face. The sprinkler system at each lock consists of a pumping unit in each lock wall at each gate block, all units being interconnected. The top floors

of the central control stations are protected by sprinkler systems that furnish 1200 gallons per minute at Gatun and Miraflores, and 950 gallons per minute at Pedro Miguel. A supply of 4000 gallons per minute is available for the protection of the Gatun Dry Dock.

109. Each lock is provided with recessed seats and sills for the installation of a floating caisson downstream from the unwatering miter gates and upstream from the emergency dams. The caisson, used during unwatering of the lock chambers as an aid to maintenance and repair operations, is an all-welded structure, 150 feet long, 40 feet wide, and 75 feet high. The hull consists of a steel skin plate supported on beams, girders, and intercostals. Loads are transmitted to the stem and keel supports by vertical and horizontal trusses, bulkheads, and decks. The keel and stem are 5 feet thick and the top deck is 32 feet wide. The structure contains bilge pumps, ventilation fans, and ballast chambers. Concrete ballast is located in the keel for the full length of the hull. Water-ballast tanks are located in the center of the hull. Ballast is removed by four vertical-lift pumps with a total capacity of 22,000 gallons per minute. The submerging and refloating of the caisson during placing operations is accomplished by adding or removing water ballast.

110. Installation and removal of the miter gates is performed with the assistance of a set of four pontoons, which are now standard equipment for the existing locks. Two sets are available: one at the Pacific Locks and one at the Atlantic Locks. Each pontoon weighs about 75 tons trimmed and has a lifting capacity of about 16 tons per foot of draft. A set of four pontoons has a lifting capacity of about 970 tons.

111. The Miraflores-Pedro Miguel railroad, connected to the Panama Railroad main line by the bridges over the existing and the new Miraflores Locks, furnishes communication between Pedro Miguel and Miraflores Locks.

Relocations

112. The construction of the Third Locks required the relocations of numerous existing installations which, in some cases, were closely involved with the disposal of excavation spoil.

113. On the Atlantic side, approximately 6 miles of the Panama Railroad between Mindi and Quebrancha was relocated along the North Fork of the Agua Clara River. The new line is about 2 miles shorter, and is an improvement with respect to grade and alignment, but requires a spur to serve the existing Gatun Locks. Connections with the railroad provided for: (1) A temporary crossover on the north plug; (2) A connection to a U. S. Army supply depot near Fort Davis; (3) A permanent crossover for service to installations between the existing and the new locks; and

(4) Access spurs to connect the main line with the tracks to the locks backfill. Other important relocations were those of highways, the Fort Davis buildings, the Mindi Powder Dock, and water mains and other municipal facilities. Means for handling drainage were also developed. Spoil disposal was made generally in the deep ravines and marshy low lands characteristic of the near-by topography, for the purpose of ultimate development and use of the areas thus formed. Where necessary, for future use as backfill, the material was separated into selected classes and stored. There were nine spoil areas on the Atlantic side.

114. The disposal of spoil on the Pacific Locks was not controlled by existing developments; however, the material was located for future utilization of the areas where possible. There were four spoil areas at Pedro Miguel and seven at Miraflores. A railroad was designed to serve installations on the west bank of the Canal between Miraflores and Pedro Miguel Locks. It connects with the Panama Railroad near Fort Clayton, and crosses on the bridge over the existing Miraflores Locks. Provision has been made for the relocations of highways and other facilities, including drainage diversions, where necessary.

Protection

115. Almost every feature of the Third Locks was affected or influenced in some degree by measures for protection from damage caused deliberately or accidentally. The criteria for the design of such measures were obtained from all available sources of information, including scale model tests and tests on several full-size models. In so far as practicable, these measures provide against, or are designed to minimize, the effect of explosives from within the chambers or from the air, and the effects of fire. The degree of protection varies with the importance of the features for operation and the facility of restoration in case of damage. Much original work was required in the development and application of the criteria used.

Conversion to Sea Level

116. A preliminary plan for conversion of the Panama Canal to sea level involves the successive elimination of the existing lock chambers and the simultaneous lowering of Gatun Lake. The lake would be lowered by suitable stages to elevation 55 with removal of the Pedro Miguel Lock and the upper chamber at Gatun Locks, to elevation 23 with removal of the middle chamber at Gatun and the upper chamber at Miraflores, and then to sea level. Although no authorized project exists for conversion to sea level, the design of the Third Locks was influenced to some extent by such possibility, and several features were modified at a slight increased cost to effect large savings when, and if, conversion should be undertaken.

117. To avoid the risk and cost of underpinning, the gate-bay floors and adjacent walls at the lower ends of the Gatun and Miraflores upper chambers and the Gatun middle chamber were placed at the same elevation as the floor of the next lower chamber in each case. This will furnish the necessary navigable depth in the lock chambers, without alterations to walls or floors. Gate sills have been installed under the normal sill where required so that miter gates can be lowered expeditiously. The elevations of the operating machinery would not be altered by these operations. Quoin anchors, pintles, caisson seats and slots, and chain-fender machinery were designed to serve during conversion. If tidal locks are found necessary, the lower lock at Miraflores might be used by reversing certain miter gates and their machinery.

Maintenance Facilities and Procedure

118. Concurrently with the design of the various appurtenances for the Third Locks, special equipment and methods for use in their maintenance were developed. Interchangeability and accessibility of equipment were emphasized in all designs. All features requiring periodic overhaul may be removed without unwatering the lock chamber and without laying-up the lock for more than a few hours.

119. Each lock has a shop outfitted to perform necessary carpenter work and machine and electrical repairs. Facilities are provided for maintenance of all regular tools and ordinary sized equipment.

120. The major features that require special provisions for maintenance are the miter gates, the towing locomotives, the culvert valves, and the emergency dams.

121. The facilities for maintenance of miter gates include (1) provision of anchorages for 90-ton, stiff-leg derricks at selected locations in the gate bays, (2) modification of existing 4-unit pontoons for use in installation and removal for overhaul of the gates, (3) a quoin cofferdam for overhaul and inspection of fixed quoins and pintle bearings, (4) attachment of the pintle to the gates with its fitted bushing, (5) provision for unwatering the crank recess independently of the lock chamber, and (6) construction of a dry dock at Pedro Miguel for use in overhauling the miter gates.

122. The main culverts are designed for the installation of removable steel bulkheads that permit unwatering of the valve chambers. The bulkheads are constructed in sections, and they, as well as the valves, are handled by portable electric hoists. Similar installations and method of handling are used at the emergency-dam culverts and at the downstream end of the surge-reservoir culvert. The bulkheads at the upstream end of the surge-reservoir culvert are handled by a crane from the lock walls. The lateral culverts have bulkheads made of 8-inch I-beams, which are handled by locomotive hoists.

123. Cathodic protection has been provided for the miter gates and valves to increase the interval between their overhauls.

124. Towing-locomotive repair shops with complete facilities for dismantling and assembling the locomotives are located on each wall at the three lock sites.

125. At the three lock sites the towing-locomotive tracks communicate with the Panama Railroad tracks.

126. Air and water supplies, and electrical power are available at all areas occupied by equipment.

127. A caisson has been provided for the recess opening of the emergency dam which will permit maintenance in place without closure of the locks to traffic. The width of the locks is reduced, however, to approximately 130.5 feet when the caisson is in use.

128. Elevators of sufficient capacity to carry any routine supply or ordinary loads are installed in the operating galleries. Hatchways are provided for handling the heaviest pieces of equipment. Electric elevating trucks are provided in the gallery of each wall for lifting and conveying parts and supplies. At Gatun and Pedro Miguel, exit from the operating galleries to the service roads is possible by means of the crossovers at the unwatering gates. However, this facility is convenient for only the lower gate bay since the difference in gallery levels restricts its use for moving equipment from other gate bays.

Organization

129. In October 1940, the Design Section was composed of the following subsections: Bridges and Tunnels, Civil, Hydraulics, Mechanical-Electrical, Office Engineer, Protection, and Structural. Authorized positions numbered 552, of which 150 were filled. In January 1941, the Bridges and Tunnels Subsection was changed to a unit of the Structural Section. A Specifications Subsection was established in December 1941. With minor changes, this organization continued until the major part of the design program was completed.

130. Duties of the subsections were as follows:

1. Civil. Plans and preparation of all masonry designs, relocations of railroads and highways, design analyses, preparation of all topographic and general maps, and making geologic and soil-mechanics investigations.

2. Hydraulics. Hydraulic design, analyses, and model tests. Hydrology studies. Supervision of Hydraulic Laboratory and laboratory

shops. Assembly and editing of final report on design.

3. Mechanical-Electrical. Mechanical and electrical design. Supervision of Mechanical-Electrical Laboratory.

4. Office Engineer. Supervision of drafting pool, reproduction plant, and engineering files. Expediting and inspection of materials. Preparation and distribution of monthly design reports, contract drawings, and specifications.

5. Protection. Study and research to determine means of protecting the locks structures. Supervision of Protection Laboratory.

6. Specifications. Preparation of general provisions and editing of technical provisions of all specifications for supply and construction contracts.

7. Structural. Design of miter gates, valves, bulkheads, bridges, caissons, and pontoons.

131. The number of employees in the Design Section reached a peak of 606 in April 1942. An organization chart is shown in Figure 2.

132. Consultants in geology, foundations and soil mechanics, electrolysis and corrosion, tunnels, bridges, architecture, and general problems were employed as need for their services arose.

CONSTRUCTION

General

133. The construction program was originally scheduled for a six-year period, beginning July 1939, and ending June 1945. However, the authorization Act was not passed until August 1939, and the first funds were appropriated to become available in July 1940. Due to the defense character of the project and as a result of the European war and its trends, the completion date of June 1945 was retained and work schedules were altered to conform. This schedule required the utilization of existing (regular Panama Canal) construction forces on such preliminary work that could be accomplished without complete plans, and on other features that fitted into the operating functions of these forces. Some of the work was so intimately connected with existing facilities as to preclude consideration of execution by contract. In general, preliminary estimates indicated that savings might be effected and schedules assured with contract operations if competitive interest could be developed similar to that which usually obtains on comparable work in the United States. Therefore, all

major construction, except dredging for the approach channels, was planned and scheduled for execution by contract. The scheduled operations were being maintained within reasonable limits up to the modification of the program on May 25, 1942.

Construction Planning

134. Comprehensive studies were made on major operations required to complete the construction on schedule. This work included detailed plant layouts and probable methods to be employed, with estimates of cost of several alternatives.

135. The studies furnished a guide for determining if contract- or hired-labor should be used for certain features, and for establishing the size of utilities to be built for construction personnel and operations. They also served as an index for comparison with bidders' proposals, were used for budgeting, and would have furnished competent information for the procurement of construction equipment if Government forces had undertaken operations that had been planned for contract.

136. Rates of supply for cement and aggregates and storage requirements were established within the limits required for contract and shipping arrangements. These features were particularly important since they involved manufacturing or processing, storage, and loading by one or more contractors, transportation by other organizations, and unloading, storage, and use by other contractors. The various specifications contain the conditions established for these operations.

137. The selection of construction equipment best suited to the operations under tropical weather conditions and estimates of its productive capacity were essential for use in preparing the cost estimates that were made concurrently.

138. Schedules of operations required close coordination with the development of the design, which was generally the controlling factor in starting the several features.

Atlantic Area

139. The construction work was divided between the Atlantic Area and the Pacific Area. The former had all field work related to the new Gatun Locks and the latter had the field work related to the new Pedro Miguel and Miraflores Locks. The work in each of these areas was directed by an Area Engineer.

140. The work accomplished in the Atlantic Area was:

1. Excavation for the lock structures.

2. Dredging for the approach channels.

3. Relocation of the Panama Railroad main line from Mindi to Quebrancha.

4. Relocation of the Panama Railroad connection to Gatun over the north plug to permit dredging to proceed, and the relocation of a spur to serve a U. S. Army facility.

5. Relocation of Bolivar Highway.

6. Relocation of several facilities in the Fort Davis military reservation, including buildings, roads, and drainage.

7. Relocation of the 44-kv and 6.6-kv distribution lines of the Panama Canal electrical system.

8. Installation of the permanent emergency power plant and frequency changer in a temporary construction power plant to serve construction operations.

9. Construction of the town of Margarita, complete with all community facilities.

10. Relocation of Mindi Dock and its connecting railroad spur.

11. Relocation of the Gatun water supply reservoir and the 16-inch connection to the Mount Hope water supply.

12. Construction of Gatun Silver town for laborers.

141. All relocations and town construction except grades for the railroad were done by Divisions of The Panama Canal. The excavation for the locks structure and the construction of the railroad grades were done by contract. The installations of the mechanical and electrical equipment in the power plant were done by contract, and the building, cooling tower, and switching stations were constructed by the appropriate Panama Canal Divisions.

142. The major features of work were the excavation for the locks structure and the construction of the subgrade for the Panama Railroad relocation. They were done under one contract with the Martin Wunderlich Company and Okes Construction Company, as joint ventures. The operations were noteworthy for the excellent results obtained with modern disposal equipment under tropical conditions. The major equipment employed is shown on Appendix A.

143. The quantities and costs of the work are shown in Appendix C.

Pacific Area

144. The work in the Pacific Area included the bridge over the existing Miraflores Locks and the aggregate processing plants at Miraflores and Gamboa, as well as the work directly related to the new Pedro Miguel and Miraflores Locks.

145. The work accomplished in the Pacific Area was:

1. Excavation for all the Miraflores Locks structures, except about 1,045,000 cubic yards of basalt and 200,000 cubic yards of earth near the north end of the upper chamber.

2. Dredging for the approach channels to Miraflores Locks.

3. Construction of the bridge over the existing Miraflores Locks.

4. Construction of railroad and highway grades to serve between the new bridge at Miraflores and the new Pedro Miguel Lock site.

5. Construction of the towns of Cocoli (Gold) and Cocoli (Silver).

6. Minor relocations of utilities from the lock areas.

7. Construction of aggregate processing plants at Gamboa and Miraflores.

8. Crushing and stock-piling about 259,000 cubic yards of 8-inch basalt for processing into concrete aggregate.

9. Installation of the permanent emergency power plants and frequency changers of the new Pedro Miguel and Miraflores Locks in a temporary construction power plant at Miraflores to serve construction operations.

146. About one-half of the buildings in Cocoli (Gold) were constructed by contract. All other buildings, municipal utilities, and relocations except railroad and highway subgrades mentioned in (4) in the preceding paragraph were constructed by the appropriate Panama Canal Divisions. Dredging of the approach channels, except the north approach channel to the new Pedro Miguel Lock, was done by the Dredging Division. Excavation for the lock structures and certain railroad and highway grading were done by contract. The substructure and paving of the Miraflores Bridge were constructed by the Municipal Engineering Division, and the superstructure was done by contract. Construction of the power plant followed the same procedure as at Gatun with the same installation contractors.

147. The major operation was the excavation for the new Miraflores Locks, which was done under contract by Panama Constructors, Inc. Combined with this work were the construction of railroad and highway grades mentioned in (4) in Paragraph 145, and the crushing of 259,000 cubic yards of basalt. The major equipment employed on the work is shown in Appendix B.

148. The quantities and costs of the work are shown in Appendix C.

Concrete Aggregates

149. As a result of studies on the available sources of aggregates, the Chagres River deposit near Gamboa was selected for the sand and gravel. The gravel was to be supplemented by basalt from the Miraflores excavation crushed into the larger sizes. The Chagres supply was to be delivered by barge to the sites, as was the Gatun demand for Miraflores basalt. The estimated quantities to be processed were 9,000,000 tons of Chagres River aggregate and 2,500,000 tons of crushed rock.

150. The sand was to be graded in two sizes: No. 8 to No. 100, and 3/8 inch to No. 8. The gravel was to be graded in three sizes: 3/4 inch to 3/8 inch, 1-1/2 inches to 3/4 inch, and 6 inches to 1-1/2 inches. The crushed stone was to conform to the last two gradings of the gravel.

Dredging

151. Out of a total of 80,000,000 cubic yards of excavation for the project, approximately 31,000,000 was adapted to economical removal by dredging. Approximately 6,000,000 cubic yards of this amount is in the dikes (plugs) which will be left in place until completion of all work required in the dry. The remainder is in the approach channels between the dikes and the existing Canal channels. The volumes at the various locations are:

Gatun North Approach	8,432,700 cubic yards
Gatun Plugs (2)	1,822,900
Channel between Miraflores and Pedro Miguel	4,470,000
Miraflores Plugs (2)	2,742,900
Pedro Miguel Plugs (3)	1,404,200
Miraflores South Approach	12,127,300
Total	31,000,000 cubic yards

152. The dredging is being done by the Dredging Division, which had considerable equipment and an experienced organization. The existing

facilities were supplemented by new equipment where necessary to complete the work on schedule. Approximately $7,300,000 of new equipment was acquired, which included a new 28-inch, 5000-horsepower hydraulic dredge. A part of the equipment was to be used for dredging raw concrete aggregates at Gamboa and transporting the aggregates to the sites of the work.

Concrete

153. The Third Locks structures were estimated to require about 6,000,000 cubic yards of concrete, distributed as follows: Gatun, 2,500,000 cubic yards; Pedro Miguel, 1,600,000 cubic yards; and Miraflores, 1,900,000 cubic yards.

154. Standard low-heat Portland cement was specified. Additional measures to minimize temperature cracks were (1) the use of flake-ice or refrigeration to give a placing temperature not to exceed 75 degrees Fahrenheit, and (2) limitations on concrete placing to 5-foot lifts with 5-day intervals between successive lifts. In certain locations, such as the first lift above the rock and where high-strength concrete was to be used, the lifts were reduced to 2-1/2 feet. These precautions were deemed necessary because the operating machines and control were located below ordinary water levels.

155. A concrete strength of 3500 pounds per square inch in 90 days was contemplated for the major structures. A relatively small amount of concrete with a strength of 5000 pounds per square inch was specified for some areas.

156. Proportioning was to be determined in the field to meet the immediate conditions of placing. It was estimated that the cement content would average about 1.1 barrels per cubic yard.

157. Although the major parts of the structures were designed as gravity sections, the concrete was heavily reinforced. Some reinforcement was required for working stresses, but most of it was planned for shock loads. The reinforcement near the top of the walls was continuous across the joints.

158. A large laboratory was constructed and equipped to conduct investigations and tests on the concrete and its materials, and to make chemical and physical analyses of all other common construction materials. Facilities for storage of concrete test specimens were to be provided at the lock sites.

Contracts

159. The work to be done by contract was divided, in so far as practicable, according to its character and geographical location. This division

reduced the magnitude of individual undertakings and permitted wider competition, a particularly important element on the excavation and lock construction contracts. Where required, the work under a contract was subdivided into parts, with completion of parts coordinated with schedules of other work. Such subdivisions were designed to complete the project on time with the greatest period of use of equipment and labor. Upon modification, the necessity for such rigid scheduling of subdivisions was eliminated and the contractors were granted greater latitude on the work as a whole. A brief resumé of the contracts follows:

1. "Excavation, New Gatun Locks Structure, South Approach Channel, and Appurtenant Work." Contract No. PClp-571.
Contractor: Martin Wunderlich Company and Okes Construction Company.
Amount: $8,517,100.00 Earnings: $11,039,917.54
Bids Opened: December 4, 1940 Contract dated: January 6, 1941
Work Completed: October 9, 1943.
The work was composed of the removal of about 13,200,000 cubic yards of material for the new Gatun Locks, and the construction of the railroad grades for relocation of the Panama Railroad, including a temporary plug crossover and a "warehouse" spur.

2. "Excavation, New Miraflores Locks Structure, New Pedro Miguel Lock Structure, Pedro Miguel North Approach Channel, and Appurtenant Work." Contract No. PClp-602.
Contractor: Panama Constructors, Inc.*
Amount: $22,436,086.00 Earnings: $13,792,477.13
Bids opened: April 17, 1941 Contract dated: April 24, 1941
Work Completed (As modified): August 28, 1943.
The original work was composed of approximately 27,944,000 cubic yards of excavation, the rough processing of 2,150,000 cubic yards of basalt for concrete aggregate, the grading for the relocation of Bruja Highway and connections between the existing and the new Miraflores Locks, and the grading for a railroad between the new Miraflores Bridge and the new Pedro Miguel Lock via the new Miraflores Locks. As a result of the modification, all work at Pedro Miguel was suspended and that at Miraflores was reduced. Because of the large reduction in the amount of work, the Government purchased the contractor's complete plant and equipment, and adjusted the contractor's unit prices to conform.

3. "Construction of Bridge Over Existing Miraflores Locks, Swing Spans and East Approach Viaduct Superstructures and Appurtenant Works." Contract No. PClp-583.

* A corporation organized for this work and formed by the S. A. Healy Company, Henry J. Kaiser Company and The Kaiser Company, Morrison-Knudsen Company, Inc., J. F. Shea Company, Inc., Walsh Construction Company, Hawaiian Dredging Company, Ltd., and S. D. Bechtel.

Contractor: Pittsburgh-Des Moines Steel Company.
Amount: $1,078,840.00 Earnings: $1,126,752.03
Bids Opened: March 12, 1941 Contract dated: March 22, 1941
Work Completed: June 2, 1942
The contract provided for the fabrication and erection of two bobtail swing spans across the existing Miraflores Locks and of an east approach viaduct to the east span. The substructure was constructed by hired labor. The bridge was opened to traffic May 20, 1942.

4. "Processing Concrete Aggregates for Third Locks Project." Contract No. PClp-623.
Contractor: Nevada Constructors, Inc.*
Amount: $6,880,800.00 Earnings: $2,443,943.33
Bids Opened: September 10, 1941 Contract dated: September 29, 1941
Work Completed (As modified): October 27, 1942.
The work to be done was the processing of approximately 9,000,000 tons of Chagres River aggregate at Gamboa and about 2,500,000 tons of basalt at the new Miraflores Locks site, and the loading of about 7,200,000 tons and 740,000 tons of these aggregates, respectively, onto barges for delivery by the Government. The processing of Chagres material required the furnishing, erection, and operation of a plant to reclaim from raw storage, wash, screen, stock-pile, and load aggregates; the sand in two sizes, the gravel in three sizes, and the rock in two sizes. The processing of the basalt required the furnishing, erection, and operation of a plant to reclaim the material previously crushed to six inches from storage, wash, recrush, screen, stock-pile, and load onto barges. The maximum daily demand for sand and gravel was placed at 20,000 tons and for crushed rock at 9000 tons (4000 tons to Gatun). The contract was modified, when construction was suspended, to provide for the substantial completion of the plants except for certain equipment to be placed in storage.

5. "Furnishing Portland Cement." Contracts Nos. PClp-624 and PClp-625.
Contractors: Trinity Portland Cement Company
Lone Star Cement Corporation
Amounts: $5,400,000.00 Earnings: $668,564.58
$2,790,000.00 $168,150.06
Bids Opened: August 11, 1941 Contracts dated: August 30, 1941
Final Payment (As modified): September 1944 (Estimated)
Final Payment (As modified): April 10, 1943
These contracts were for the furnishing of 4,000,000 barrels and 2,000,000 barrels, respectively, of low-heat Portland cement in bulk, loaded into Government ships at Houston, Texas. Delivery was to be

* A corporation organized for this work composed of W. E. Callahan Construction Company, Gunther & Shirley Company, Griffith Company, American Concrete & Steel Pipe Company, J. C. Maguire & Company, and John D. Gregg.

made at a maximum rate of 215,000 barrels in any one month or 100,000 barrels in any 10-day period, and 150,000 barrels in any one month, respectively. Operations on facilities to perform this work were in progress when the project was modified May 26, 1942. No cement was delivered under the contracts.

6. "Construction of Contract Quarters." Contract No. PClp-651.
Contractor: MacDonald Construction Company.
Amount: $606,386.00 Earnings: $615,938.29
Bids Opened: November 19, 1941 Contract dated: November 25, 1941
Work Completed: September 2, 1942
The contract provided for the construction of 117 family quarters in 35 buildings and two 40-room bachelor buildings located at Cocoli. The construction of two four-family quarters was transferred later to Gamboa. Certain plumbing fixtures and equipment were supplied by the Government.

7. "Furnishing Emergency Power Plants." Contract No. PClp-653.
Contractor: Busch-Sulzer Bros. Diesel Engine Company.
Amount: $1,661,926.00 Earnings: $1,816,756.49
Bids Opened: November 15, 1941 Contract dated: December 1, 1941
Work Completed: August 10, 1942
This contract was for furnishing seven 2500-kw, 60-cycle, 11.5-kv, diesel-electric generating units with plant auxiliaries for installation in the three sets of locks. The units are designed to be placed inside the lock walls as an emergency stand-by but were to supply 60-cycle power for construction operations after installation in temporary settings.

8. "Construction of New Gatun Locks and Appurtenant Work."
Contract No. PClp-659.
Contractor: Rosoff Panama Construction Company, Inc.
Amount: $45,705,000.00 Earnings: $1,506,811.96
Bids Opened: January 6, 1942 Contract dated: February 23, 1942
Final payment (As modified): October 29, 1942
This contract was for the construction of the new Gatun Locks, involving the placing of approximately 2,555,000 cubic yards of concrete, furnishing and placing 89,600,000 pounds of reinforcing steel and large amounts of other materials, some of which were to be furnished by the Government and some by the contractor. The work was to be completed within 1095 calendar days. As previously noted, the work was scheduled for certain stages of completion by parts to permit other operations and installations to proceed so that upon its completion the locks would be ready for transiting vessels. The contractor was well advanced in his mobilization and planning when the work was suspended May 26, 1942. No physical work was accomplished at the site.

9. "Furnishing Miter Gates, Valves and Bulkheads." Contract No. PC1p-671.
Contractor: Treadwell Construction Company
Amount: $15,991,498.40 Earnings: $67,969.26
Bids Opened: March 3, 1942 Contract dated: March 12, 1942
Final payment (As modified): December 16, 1942
The work under this contract provided for the construction of 44 miter-gate leaves, 44 tainter valves, and a number of other valves and bulkheads. The work was to be accomplished within 900 calendar days. Only one bid was received in response to the advertisement and it was unsatisfactory with respect to time and price. The contract was made on satisfactory terms with another party. Planning and some mobilization for plant expansion to accomplish the work was well under way when the project was modified. No physical work had been done on the items to be furnished.

10. "Furnishing Frequency Changers." Contract No. PC1p-673.
Contractor: General Electric Company
Amount: $456,723.00 Earnings: $463,330.00
Bids Opened: March 6, 1942 Contract dated: March 16, 1942
Work Completed: January 29, 1944
This contract provided for furnishing three 25-60-cycle, synchronous frequency changers for the operation of the new locks from the existing 25-cycle system. Two units have ratings of 6000 kw and one has a rating of 3000 kw. The units are designed for installation with the emergency stand-by plants in the walls and can serve to augment the present system from the diesel-driven units.

11. "Emergency Power Plant Control and Switching Equipment." Washington Order No. 60837.*
Contractor: General Electric Company
Amount: $371,327.92 Earnings: $384,324.32
Bids Opened: August 10, 1942 Contract dated: August 14, 1942
Work Completed: August 1944 (Estimated)
This contract provides the permanent switching and control equipment for the emergency stand-by plants to be located in the lock walls. The equipment was purchased and installed with the plants in their temporary settings to augment the existing power supply and to permit use of the existing 25-cycle supply for construction through the frequency changers. It provides automatic operation of the plants from the central control stations at the locks. Push-button operation will start any one or all units in a plant, including the frequency changers, and place the power on the lines.

12. "Erection of Power Plant Equipment." Contract No. PC1p-737.

* Contract by the General Purchasing Officer but listed here because of connection with other work.

Contractor: Martin Wunderlich Company and Okes Construction Company
Amount: $146,640.00 Earnings: $183,821.48
Negotiated: December 8, 1942
Contract dated: January 7, 1943
Work Completed: February 9, 1944
The work under this contract provided for the installation of the seven emergency diesel-electric units and plant auxiliaries, except electrical work, in two temporary settings, one at Gatun and one at Cocoli.

13. "Installation of Electrical Equipment." Contract No. PC1p-779.
Contractor: Mass. Electric Construction Company
Amount: $61,235.00 Earnings: $80,000.00 (Estimated)
Bids Opened: November 16, 1943 Contract dated: November 23, 1943
Work Completed: August 30, 1944
This contract provided for the installation of all electrical equipment, including switchgear and control and the three frequency changers, in the temporary construction power plants.

160. In addition to the contracts listed in the preceding paragraph, certain contracts were handled by the General Purchasing Officer. The purchases of the dredge "Mindi", barges, and tugs for the Dredging Division were some of the major items.

161. The status of the construction contract for the Pacific Locks follows:

"Construction of New Miraflores Locks, New Pedro Miguel Lock, and Appurtenant Work."
Low bidder: Panama Constructors, Inc.
Amount of bid: $82,982,675.00 reduced to $77,982,675.00 by negotiation
Bids Opened: April 21, 1942 Bids Rejected: May 26, 1942
The award of this contract was held pending clearance from certain war agencies. The modification became effective before award was made, and bids were rejected. The contract unit prices and Government costs on this work are shown in Appendix C.

Estimates

162. Comparative estimates were prepared on all major construction features. These estimates furnished the basis for funds and budget control. Detailed estimates were prepared for all work to be performed by contract, based on the published plans and specifications for deciding whether bids were reasonable and acceptable or should be rejected and operations done by other means.

163. Table 4 shows a summary of the estimated project cost as of March 11, 1942. Another estimate was prepared as of May 15, 1942 to

BUDGET SUMMARY

MARCH 15, 1942

Feature	Total Estimate	F.Y. 1941 Cost	F.Y. 1942 Estimate	F.Y. 1943 Estimate	F.Y. 1944 Estimate	F. Y. 1945 Estimate
NEW GATUN LOCKS						
Design	$ 1,947,806	$ 242,458	$ 725,048	$ 491,150	$ 291.090	$ 198,060
Relocation - Miscl. Structures	1,603,498	500,455	564,343	308,100	230,600	--
Relocation - Fort Davis	451,048	507,035	(25,599)	(19,944)	(10,444)	--
Excavation - By-Pass Channels	3,506,448	483,962	1,027,399	296,365	807,900	890,822
Excavation - Locks Structure	11,505,039	1,574,391	6,779,865	2,629,483	521,300	--
Railroad Construction	524,546	51,911	290,281	67,654	23,400	91,300
Locks Structure	60,554,138	--	670,595	17,554,500	33,250,705	9,078,338
Sub-total	$ 80,092,523	$ 3,360,212	$ 10,031,932	$ 21,327,308	$ 35,114,551	$ 10,258,520
NEW PEDRO MIGUEL LOCKS						
Design	$ 1,321,428	$ 233,925	$ 546,325	$ 270,734	$ 160,500	$ 109,944
Excavation - By-Pass Channel	3,372,895	2,200	128,834	178,461	2,253,500	809,900
Excavation - Locks Structure	17,097,877	21,618	391,789	6,175,484	8,928,768	1,580,218
Locks Structure	28,235,992	--	--	4,120,261	18,512,850	5,602,881
Sub-total	$ 50,028,192	$ 257,743	$ 1,066,948	$ 10,744,940	$ 29,855,618	$ 8,102,943
NEW MIRAFLORES LOCKS						
Design	$ 1,196,658	$ 260,262	$ 728,627	$ 103,597	$ 61,398	$ 42,774
Relocation - Miscl. Structures	635,633	78,821	260,212	56,900	239,700	--
Excavation - By-Pass Channels	11,282,511	860,682	2,199,760	4,605,269	1,955,400	1,661,400
Excavation - Locks Structure	9,909,467	31,146	5,508,469	4,369,852	--	--
Railroad Construction	255,292	249	129,643	103,300	--	22,100
Locks Structure	38,947,071	--	21,000	13,317,779	20,295,812	5,312,480
Bridge Over Existing Locks	2,528,058	870,213	1,657,845	--	--	--
Sub-total	$ 64,754,690	$ 2,101,373	$ 10,505,556	$ 22,556,697	$ 22,552,310	$ 7,038,754
TOWNSITES AND MISCL. CONSTRUCTION						
Margarita - Gold	$ 3,354,395	$ 1,352,113	$ 1,967,942	$ 34,340	$ --	$ --
Gatun - Silver	560,794	96,300	458,394	6,100	--	--
Cocoli - Gold (Contract)	854,135	--	830,935	23,200	--	--
Cocoli - Gold (H. L.)	2,377,886	1,238,389	1,139,497	--	--	--
Cocoli - Silver	504,840	211,246	290,069	3,525	--	--
Diablo Heights	2,448,657	1,630,781	795,891	21,985	--	--
Gamboa - Gold	1,902,172	411,047	1,451,355	39,770	--	--
Gamboa - Silver	162,985	--	162,985	--	--	--
Miscellaneous	407,568	287,939	119,629	--	--	--
Sub-total	$ 12,573,432	$ 5,227,815	$ 7,216.697	$ 128,920	$	$
GENERAL (FOR ALL LOCKS)						
Gates and Valves	$ 20,500,000	$ --	$ 400,000	$ 5,100,000	$ 10,000,000	$ 5,000,000
Caissons	1,120,000	--	--	--	672,000	448,000
Deck Plate	--	--	--	--	--	--
Bridge Over New Locks	1,000,000	--	--	--	400,000	600,000
Miscl. Structural Items	--	--	--	--	--	--
Elec. & Mech. Equipment	42,391,976	--	700,000	4,897,700	23,962,976	12,831,300
Installation of Elec. & Mech.	--	--	--	--	--	--
Contingencies	4,539,187	--	--	4,539,187	--	--
Sub-total	$ 69,551,163	$ --	$ 1,100,000	$ 14,536,887	$ 35,034,976	$ 18,879,300
DISTRIBUTIVE						
Advance Payments						
Atlantic Excavation (Wunderlich)	$ --	$ 76,467	$ (76,467)	$ --	$ --	$ --
Pacific Excav. (Panama Constr's)	--	--	620,892	(620,892)	--	--
Gatun Locks (Rosoff)	--	--	1,772,800	538,650	(2,311,450)	--
Pacific Locks (Panama Constr's)	--	--	--	3,385,500	(3,385,500)	--
Aggregate Proc. (Nevada Constr's)	--	--	665,000	(27,500)	(637,500)	--
Gates & Valves (Treadwell)	--	--	--	--	--	--
Railroad Materials	--	--	127,440	(80,000)	(9,000)	(38,440)
Construction Equip. & Plant						
Dredging Division	--	926,828	4,355,285	3,277,750	(457,867)	(8,101,996)
Transportation Division	--	110,641	164,055	(25,000)	(125,000)	(124,696)
Special Engineering Division	--	72,133	100,000	(30,000)	(72,133)	(70,000)
Cement - Undistributed	--	--	3,000	520,969	(167,669)	(356,300)
Aggregate - Undistributed	--	14,254	475,322	522,303	(321,233)	(690,646)
Overhead	--	72,134	(72,134)	--	--	--
Construction Buildings	--	265,970	50,000	(125,000)	(125,000)	(65,970)
Deferred Design	--	373,650	(373,650)	--	--	--
Sub-total	$ --	$ 1,912,077	$ 7,811,543	$ 7,336,780	$ (7,612,352)	$ (9,448,048)
TOTAL	$277,000,000	$12,859,220	$ 37,732,676	$ 76,631,532	$114,945,103	$ 34,831,469

NOTE: Amounts enclosed in parentheses denote credit.

TABLE 4

reflect the increased cost and contingencies of work under the war conditions. However, the modification of the project on May 25, 1942 deferred the work involved.

Costs

164. An effort was made to obtain detailed unit costs on all work done. In some cases, the accounting procedures on work done by hired-labor force did not permit accurate unit costs, the costs being limited to the total cost of a feature. In general, however, unit costs were obtained on such work in reasonably close approximations.

165. Unit costs were obtained on all contract operations. These costs were based upon distributions from pay rolls, invoices, and field observations. Usually, the distributions made by the Government representatives and the contractor were compared and reconciled. The costs obtained should prove of considerable value in estimating future works and in negotiations with the contractors. The Government costs and contract unit prices are shown in detail in Appendix C.

166. The costs of work done to June 30, 1944, are shown in detail in Appendix C. The contract unit prices on contracts which were terminated and on which award was pending are also shown for convenient reference. The period of major hired-labor operations was from about July 1940 to June 1942, and the period of major contract operations was from April 1941 to August 1943. Contract prices were established or received for the several features between December 1940 and April 1942. The costs reflect the difficult labor and material procurement conditions prevalent during the period. The later contract prices not only reflect these conditions but are believed to contain large contingencies for transportation difficulties and other indeterminate war risks, although the contracts contained certain remedial clauses.

167. For convenient reference, the average wage rates prevailing April 1, 1942 for work being done by the United States Government on the Isthmus and the average of two major Third Locks contractors are shown in Appendix D, and the Freight Tariffs between New York and Cristobal, C. Z., are shown in Appendix E.

Organization

168. The organization of personnel for construction activities was divided between the main office and the field offices. The Construction Engineer supervised all construction work. The field work was divided into two areas with an Area Engineer in charge of each. The main office

group was divided into Operations and Office Sections. These two sections, in effect, served as a technical staff for the Construction Engineer. They collaborated closely with the Area Engineers and with other sections on schedules and matters affecting construction operations. Figure 2 shows the organization contemplated for the peak of activities. The actual peak reached was 277 in June 1942.

TOWNSITES AND ADMINISTRATION

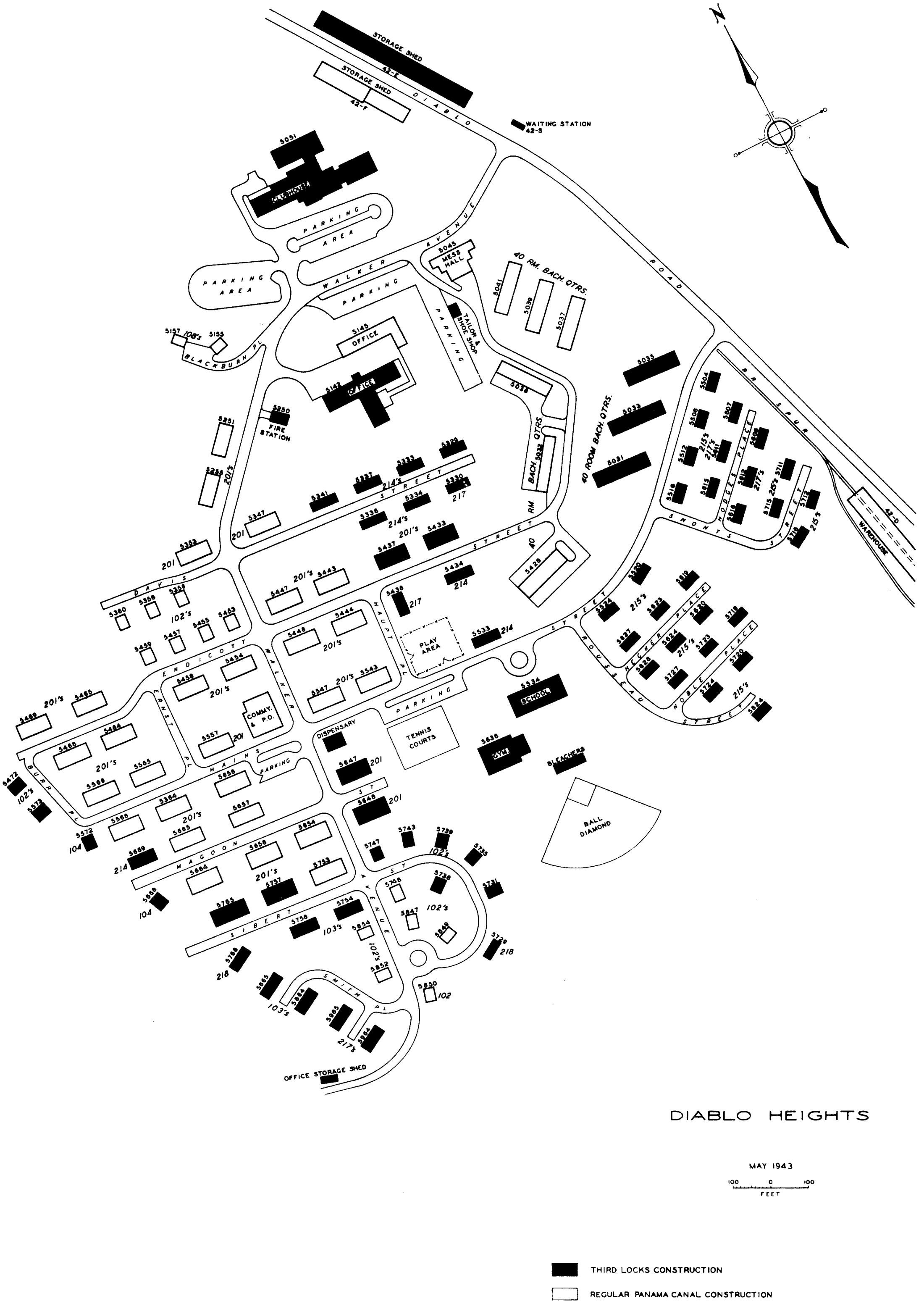
Towns and Employee Housing

169. Three new towns were constructed for the purpose of housing Government and contractors' employees: Diablo Heights, north of Balboa; Margarita, between Cristobal and Gatun; and Cocoli, on the west bank of the Canal, near Miraflores Locks. Maps of these towns are shown in Figures 17, 18, and 19, respectively. Each town includes a commissary, post office, dispensary, school, and clubhouse. Gymnasiums, tennis courts, and ball fields are among the recreational facilities provided. The clubhouses have moving-picture theaters, bowling alleys, and billiard tables. Additional quarters were constructed also in the existing town of Gamboa. Figure 20 shows the Gamboa developments.

170. All Government-built houses are constructed of wood, and a large percentage of their exterior wall space is opened to allow for adequate ventilation. All houses are screened. Most of the buildings were designed for occupancy by two to twelve families. Construction of the 12-family type was abandoned in 1941 because personnel was affected adversely by the close proximity resulting from the open-type construction. Space for parking cars and for washing clothes is available under all the buildings. All quarters, except the 12-family, have sufficient space for recreation. All quarters are furnished with beds, tables, chairs, ice boxes, and electric ranges.

171. Construction of Diablo Heights was started in 1939 to house temporary workers on some special projects, but later the town was expanded and facilities were increased to provide for the Third Locks organization. The headquarters of the Special Engineering Division was located in Diablo Heights. Field office buildings were constructed near the lock sites.

172. Certain areas in the new towns were reserved for quarters to be built by the contractors for their employees. The contractors graded these areas and provided all utilities within their assigned limits. Some Government-furnished quarters were made available to the contractors.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CLUBHOUSE
PARKING AREA
PARKING AREA
WALKER AVENUE
PARKING
5045
MESS HALL
TAILOR & SHOE SHOP
PARKING
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5157 108's 5155
BLACKBURN PL
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OFFICE
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BACH. 5032 QTRS.
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217
HAUPT PL
PLAY AREA
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BALL DIAMOND
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SMITH PL
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OFFICE STORAGE SHED
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5507
5512
215's
217's
5511
HODGES PLACE
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217's
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5816
STREET
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215's
SHONTS
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WAREHOUSE
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215's
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HECKER PLACE
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NOBLE PLACE
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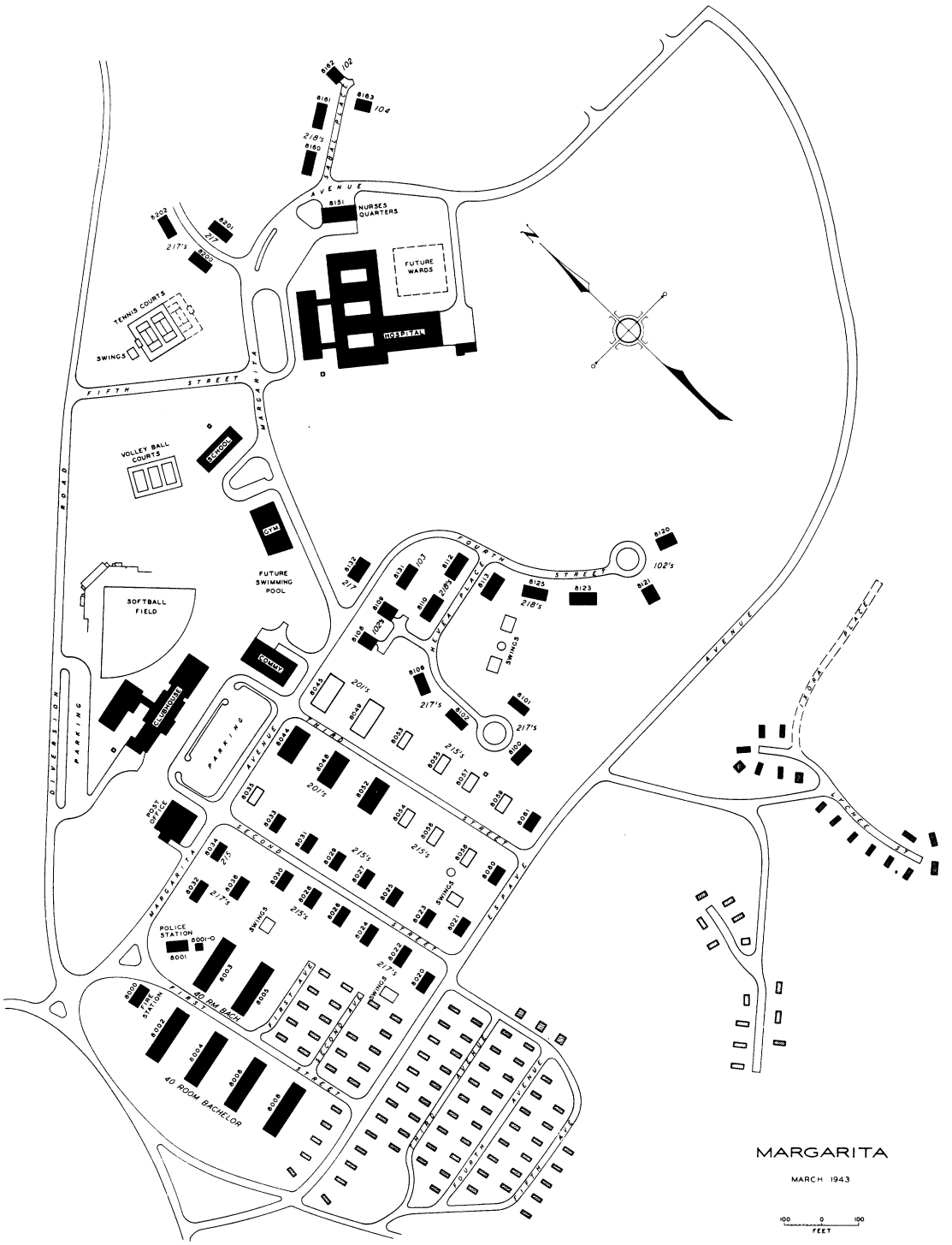
ROUSSEAU STREET
STREET

FIGURE 17


NURSES QUARTERS
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HOSPITAL
TENNIS COURTS
SWINGS
VOLLEY BALL COURTS
SEWAGE
GYM
FUTURE SWIMMING POOL
SOFTBALL FIELD
LAUNDRY
MESS HOUSE
PARKING
POST OFFICE
POLICE STATION
FIRE STATION
40 RM BACH
40 ROOM BACHELOR
FIFTH STREET
FOURTH STREET
THIRD STREET
SECOND STREET
FIRST STREET
AVENUE
MARGARITA
MARCH 1943
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THIRD LOCKS CONTRACTORS CONSTRUCTION PURCHASED BY THIRD LOCKS
THIRD LOCKS CONTRACTORS CONSTRUCTION
REGULAR PANAMA CANAL COSTRUCTION

FIGURE 18

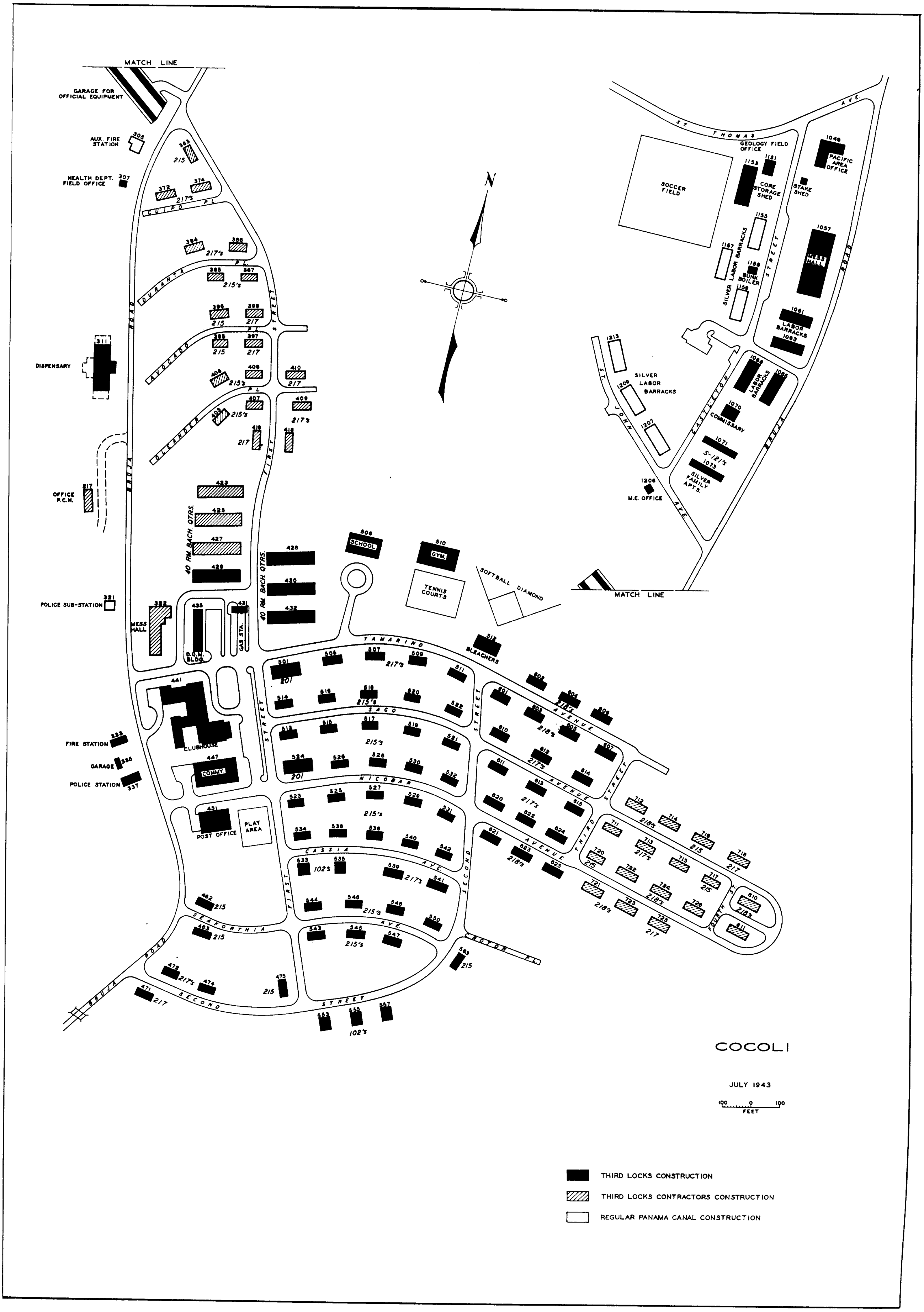

MATCH LINE
GARAGE FOR OFFICIAL EQUIPMENT
AUX. FIRE STATION
HEALTH DEPT. FIELD OFFICE
DISPENSARY
OFFICE P.C.H.
POLICE SUB-STATION
MESS HALL
D.O.M. BLDG.
GAS STA.
40 RM. BACH. QTRS.
CUIPO PL.
DURANTA PL.
AVOCADO PL.
OLEANDER PL.
BRUJA ROAD
FIRST STREET
SCHOOL
GYM.
TENNIS COURTS
SOFTBALL DIAMOND
BLEACHERS
CLUBHOUSE
COMMY.
FIRE STATION
GARAGE
POLICE STATION
POST OFFICE
PLAY AREA
TAMARIND AVENUE
SAGO
NICOBAR
CASSIA AVE
SEAFORTHIA AVE
CROTON PL.
SECOND STREET
THIRD STREET
FOURTH ST.
ST. THOMAS AVE
SOCCER FIELD
GEOLOGY FIELD OFFICE
CORE STORAGE SHED
SILVER LABOR BARRACKS
BUNK BOILER
STAKE SHED
PACIFIC AREA OFFICE
MESS HALL
LABOR BARRACKS
COMMISSARY
SILVER FAMILY APTS.
M.E. OFFICE
ST. JOHN AVE
CASTLETON
COCOLI
JULY 1943
FEET
THIRD LOCKS CONSTRUCTION
THIRD LOCKS CONTRACTORS CONSTRUCTION
REGULAR PANAMA CANAL CONSTRUCTION

FIGURE 19

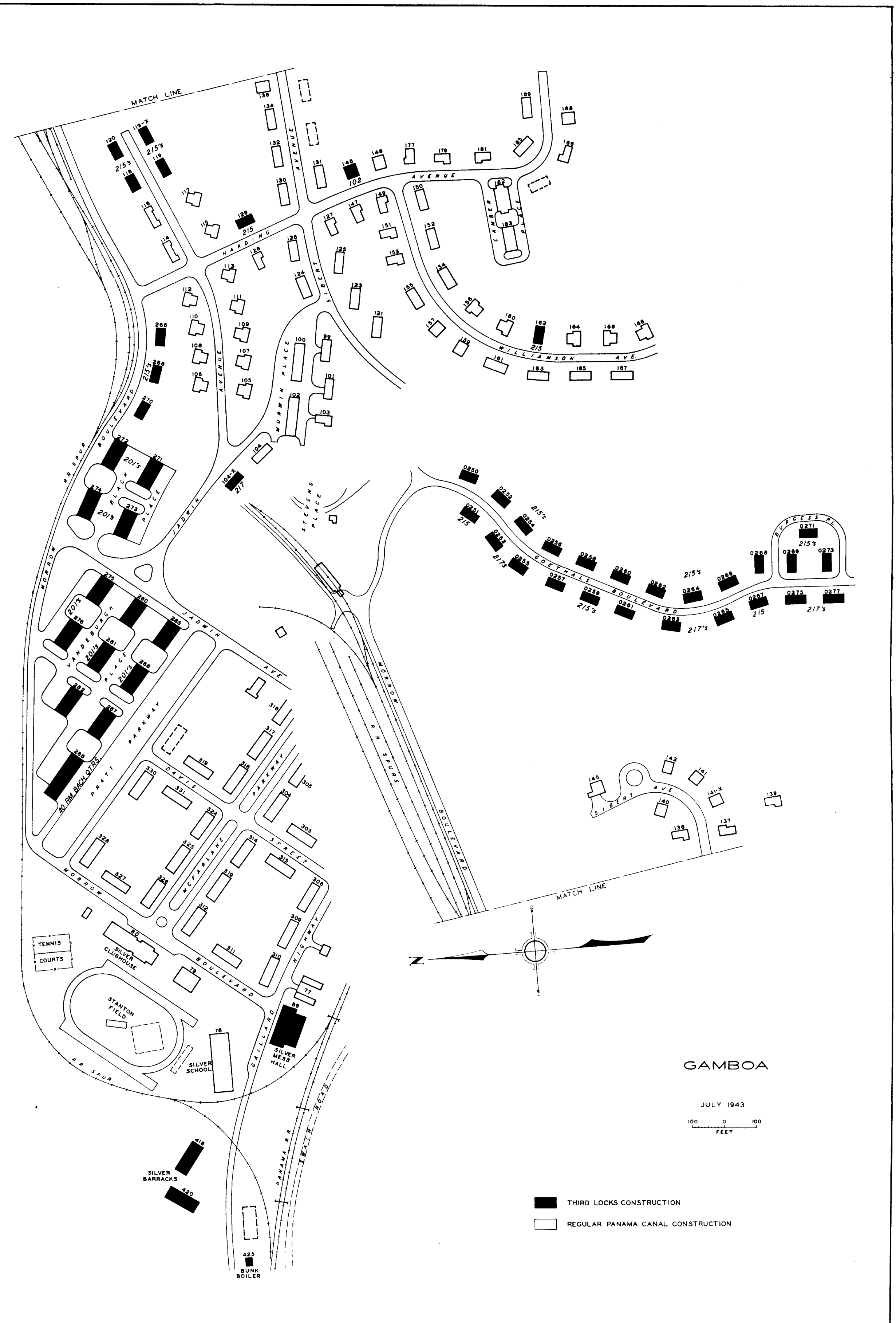

MATCH LINE
HARDING
AVENUE
SIBERT
CAMBER PLACE
WILLIAMSON AVE.
MURWIN PLACE
JADWIN
BLACK PLACE
STEVENS PLACE
R R SPUR
MORROW BOULEVARD
GOETHALS BOULEVARD
BURGESS PL
VANDEBURGH PLACE
40 RM. BACH. QTRS.
PRATT PARKWAY
DAVIS
PARKWAY
STREET
MCFARLANE
HIGHWAY
JADWIN AVE
MORROW R R SPURS BOULEVARD
SIBERT AVE
TENNIS COURTS
SILVER CLUBHOUSE
STANTON FIELD
SILVER SCHOOL
GAILLARD
SILVER MESS HALL
PANAMA R R
ROAD
SILVER BARRACKS
BUNK BOILER
GAMBOA
JULY 1943
100 0 100
FEET
THIRD LOCKS CONSTRUCTION
REGULAR PANAMA CANAL CONSTRUCTION

FIGURE 20

173. The number of Third Locks quarters in each of the three towns and the expansion in Gamboa is as follows:

	Family Quarters	Bachelor Quarters*
Diablo Heights	260	120
Cocoli	382**	300
Margarita	193***	240
Gamboa	281	40
Totals	1116	700

Quarters for laborers were constructed as follows:

	Family Quarters	Bachelor Quarters (288 Bunks)
Cocoli	24	4
Gatun	--	7
Gamboa	--	2
La Boca	--	4****

Mess halls for laborers were constructed at Gatun, Cocoli, and La Boca.

174. All buildings, except those built by the excavation contractors and 117 quarters at Cocoli and Gamboa, were constructed by the Building Division of The Panama Canal. Municipal utilities were installed by the appropriate Panama Canal Divisions.

Administration

175. The administrative work of the division and its towns was supervised by an executive officer, designated as Assistant to the Supervising Engineer. The work was divided into three subsections: Administration, Towns, and Clubhouses.

176. The Administration Subsection was composed of units handling personnel matters, property and supply, correspondence, communication facilities, and records. The assignment of living quarters was done by the Personnel Unit. The rules used for assignment gave preference to the grade and position held in the organization, but considerable weight was

* Rooms suitable for two occupants
** Includes 126 constructed by excavation contractor
*** Includes 30 constructed by excavation contractor
**** Three with 100 bunks each

given to the individual's personal needs. Seniority within grade governed the assignments where shortages in types desired occurred. An Administrative Assistant was in charge of the unit.

177. The development of the towns was planned to meet the scheduled needs of the personnel. Various types of living quarters ranging from 12-family units to single-family cottages were constructed to meet the prospective requirements. A limited amount of landscape planting was done in each of the three towns. Recreation facilities for children and adults were provided. The designs for these works were prepared by the Office Engineering Division of The Panama Canal. The work on the towns was completed during the latter part of 1942. The Relocations Unit of the Construction Section assisted the Administration Section.

178. Upon completion of the clubhouses, their operation was taken over by the Special Engineering Division. Each clubhouse was under a manager who was given full responsibility for its operation and services. The initiative of management in improving all services was encouraged. Particular attention was given the food supply on which the bachelor employees had to depend. Much of the original equipment in the food services was replaced and enlarged to meet the expanded business. An effort was made to operate the units on a nonprofit basis in order to obtain the maximum benefits to the work. The operations were supervised by a Clubhouse Director and one or two assistants. The management of the clubhouses was returned to the regular clubhouse organization March 1, 1943 as a step in the curtailment of work under the modified project.

179. As the various features of work were completed, functions such as custody of buildings, costs, and disposal of surplus equipment were transferred to the Administration Section for handling during the period of suspended operations.

MODIFICATION OF PROGRAM

180. By directive dated May 25, 1942, the Secretary of War modified the construction of the project to conform to the over-all war program. The directive provided that the operations should be reduced to such extent as the Governor deemed practicable. In accordance with this directive the following program was adopted:

1. The excavation for the Gatun Locks structure was completed.

2. The Gatun Locks construction contract was terminated.

3. The excavation for the Pacific Locks was reduced to the major part of that for Miraflores Locks, thus eliminating work on Pedro Miguel and its north approach.

4. The bids for construction of the Pacific Locks were rejected.

5. Erection of the concrete aggregate processing plants was substantially completed and the contract terminated.

6. The contracts for the supply of cement were terminated.

7. The contract for furnishing the miter gates and valves was terminated.

8. Purchase and installation of the emergency power plant equipment was completed to augment the existing Panama Canal system.

9. The barges for the transportation of aggregates were sold prior to delivery.

10. The design of all features was completed, and contract plans and specifications were prepared.

11. Dredging of the approach channels was continued on a low priority basis.

12. All relocations in progress were completed.

181. All movable construction equipment acquired under the contract terminations and office equipment were made available to the war effort as rapidly as they became available from the work. Personnel was released to other important activities, including the armed services, as rapidly as practicable. Surplus quarters were released for provisional assignment to the regular Panama Canal organization.

182. Due to reduction in personnel, the use of Third Locks funds in financing various essential functions was reduced to that justified by protection of investments and that required for the transition period. The protection included the financing of the fire-fighting facilities and a small police force in each of the three towns, the maintenance of certain streets and utilities for a limited period, the maintenance of nonpersonal buildings, and the preservation of idle plant and equipment. In May 1944, the cost of maintenance of streets and utilities was transferred to the regular appropriations.

PLANS FOR RESUMPTION OF WORK

Suspense Work

183. The present plan is to maintain a small force during the interim

between completion of the modified program of work and resumption of construction operations. This group will have custody of the records, buildings, and equipment maintained for resumption. Certain long-term investigations on concrete materials, electrical equipment, and corrosion of metals are in progress and will be continued. Operation of the General Materials Laboratory and the Reproduction Plant on limited scales provides a useful service to other agencies. In so far as practicable, construction and office equipment and supplies have been disposed of as they became surplus to the suspense needs. Much of this equipment will require replacement. The buildings constructed for the work will require some maintenance during this period. There are other buildings constructed for special projects which may be maintained at Third Locks expense for their future usefulness. The interim force will also provide a desirable continuity of administrative personnel familiar with local operating procedures, and this should be of appreciable value to the future construction organization.

Organization of Contracts

184. The designs for the Third Locks work have been embodied in contract plans and specifications. The plans for substantially all features have been reproduced and are ready for assembling into scheduled folios. The folios have been arranged for the separate contracts. Drafts of specifications have been prepared and filed. The work has been organized for 35 contracts as shown in Table 5. It will be noted that some folios remain to be completed since certain features to be contained in them are dependent upon equipment manufacturer's details, and, therefore, must await receipt of information after procurement contracts are made. The plans for elevators, dry-dock electrical equipment, and lock entrance signals, which are relatively minor and depend upon the selection of equipment, were not completed because of the urgency for release of personnel. The general design for the net-operating machines has been developed but not detailed. Installation of these machines on the initial construction should be considered in the light of developments in the current war.

185. The plan contemplates certain operations by hired-labor and Government plant which are explained under "Operations and Schedules" in Paragraphs 196 to 214.

186. The approximate quantities involved in the contracts listed are shown in Appendix F.

Contract General Provisions

187. The specifications have been prepared with general provisions conforming to laws, regulations, and conditions prevailing in the early part of 1942. These provisions will have to be reviewed carefully and

TABLE 5

FUTURE CONTRACTS

Contract	Designation	Contract Form	Folio	Status of Drawings
1	Cement	P.S.	--	None Required
2	New Pacific Locks Construction	C.(P)	115	Completed
3	Miter Gates, Valves, and Bulkheads	P.C.	114	Completed
4	Processing Concrete Aggregates	C.	109	Completed
5	Towing Locomotives	P.C.	27	Completed
6	Bridges	C.(P)	20	Completed
7	New Gatun Locks Construction	C.(P)	112	Completed
8	Operating Machinery Motors and Brakes	P.S.	49	Completed
9	Cable Junction Boxes	P.S.	38, 39, 40	See Note 1
10	Operating Machinery	P.C.	28	Completed
11	Control and Distribution Switchgear	P.C.	34, 35, 36	Completed
12	Emergency Dam Operating Machinery	P.C.	31	Completed
13	Auxiliary Electrical Control Equipment	P.S.	37	Completed
14	Elevators	C.(P)	50	See Note 3
15	Towing Locomotive Track System	P.C.	26	Completed
16	Ventilating System	P.S.	30	Completed
17	Pumps and Connecting Piping	P.S.	29	Completed
18	Motor Operated Valves	P.S.	54	Completed
19	Electrical Equipment for Gate Drydock	P.S.	57	See Note 3
20	Compressed Air System	P.C.	32	Completed
21	Direct Current Substations	P.C.	42	Completed
22	Mechanical Equipment Installation --Pacific	C.	45	See Note 2
23	Electrical Equipment Installation --Pacific	C.	47	See Note 2
24	Sprinkler System	P.S.	55	Completed
25	Deck Plate	P.S.	117	Completed
26	Mechanical Equipment Installation --Gatun	C.	44	See Note 2
27	Electrical Equipment Installation --Gatun	C.	46	See Note 2
28	Wire and Cable	P.S.	--	None Required
29	11.5-Kv. Unit Substations	P.C.	33	Completed
30	Lighting System Equipment	P.S.	41	Completed
31	Portable Hoisting Equipment	P.S.	48	Completed

TABLE 5 (Continued)

Contract	Designation	Contract Form	Folio	Status of Drawings
32	Caisson	P.C.	19	Completed
33	Communication System	C.(P)	43	Completed
34	Entrance Signals	P.S.	56	See Note 3
--	Net Operating Machinery	P.C.	53	See Note 3

C. -- Construction
C.(P) -- Construction including procurement of materials and equipment
P.C. -- Procurement; Construction Form
P.S. -- Procurement; Supply Form

Notes:

1. Drawings for Folio 38 (New Gatun Locks) and Folio 39 (New Miraflores Locks) have been completed. Drawings for Folio 40 (New Pedro Miguel Lock) will be largely processed from drawings contained in the other folios, with some modifications.

2. To be assembled from drawings contained in other folios and from drawings to be furnished by equipment manufacturers.

3. Drawings to be made after selection of equipment desired.

modified where necessary. It now appears that particular attention should be given the "escalator clause", "delay damage clause", contractor's housing, and power supply.

188. The "escalator clause" was developed for use on the first large excavation contract in order to reduce the risk to contractors and to obtain more competition on the work. Considerable apprehension prevailed among some groups at that time that inflation might develop and the cost of labor and supplies would become prohibitive on a fixed-price contract.

189. The early clause provided payment or credit for an increase or decrease between average wages of crafts or classes of workers on the Isthmus at specified intervals as applied to the actual pay rolls, with a certain period approximating the time of bidding being used as a base. At that time large numbers of workers were being employed by agencies other than The Panama Canal, and the effect of regular stabilized wages of The Panama Canal was reduced. However, on resumption, it may be expected that only two large general employers will be in the vicinity, the regular force of The Panama Canal and the construction forces of the Third Locks contractors. Therefore, if it should be deemed advantageous to use a "labor escalator clause" on the future work, it may be desirable to use an index with a broader and more general application.

190. The index used for purchases of supplies was an average of The Panama Canal Storehouse posted prices. This index was presumed to give a true indication of the cost of certain items delivered to the Isthmus. However, on actual analysis, the pricing system of the Storehouse does not necessarily reflect current prices but is based upon the average cost of all the items in stock, old and new, with a surcharge varied from time to time as the gross financial condition changes. Therefore, the use of such posted prices may reflect a hardship upon either the Government or the contractor. Another index might be used to advantage if such adjustments are considered desirable.

191. The specifications containing work to be done in the United States provided for price adjustments based upon Department of Labor Indices.

192. The "tax escalator clause" has been in common use for a number of years.

193. The "delay-damage clause" was developed after the start of the war and was designed to alleviate the risk due to shipping problems. Its operation on a minor installation contract has been such as to commend the serious consideration of a similar clause on future installation contracts. The remote location of the work from points of manufacture may cause delays in receipt of important items of equipment. Labor imported for the job must generally be guaranteed a minimum employment period each week. Therefore, idle periods caused by nonreceipt of materials being

furnished by the Government may present an undue risk to a contractor on the equipment installation contracts which will be almost entirely labor and consequently of a high-risk nature.

194. As a result of the expansion in housing of certain other Government agencies immediately preceding the war, surpluses may be available for contractor's employees. In order for the Government to benefit from the use of such quarters that may be made available, the extent and conditions for their use should be set forth in the specifications. Both Army and Navy have groups of housing within reasonable distances of the sites whose potential use should be developed.

195. The permanent emergency power plants for Third Locks have been installed in temporary locations near the lock sites. They are designed to provide 60-cycle power either by diesel-electric generation or from the Panama Canal system through frequency changers. It is now planned that these plants will be operated by The Panama Canal as an adjunct to its system. Their continued operation by The Panama Canal during the construction period will permit the use of either hydroelectric or diesel power and safeguard the permanent equipment. The sale of standard 60-cycle current at the plant to the general contractor is contemplated.

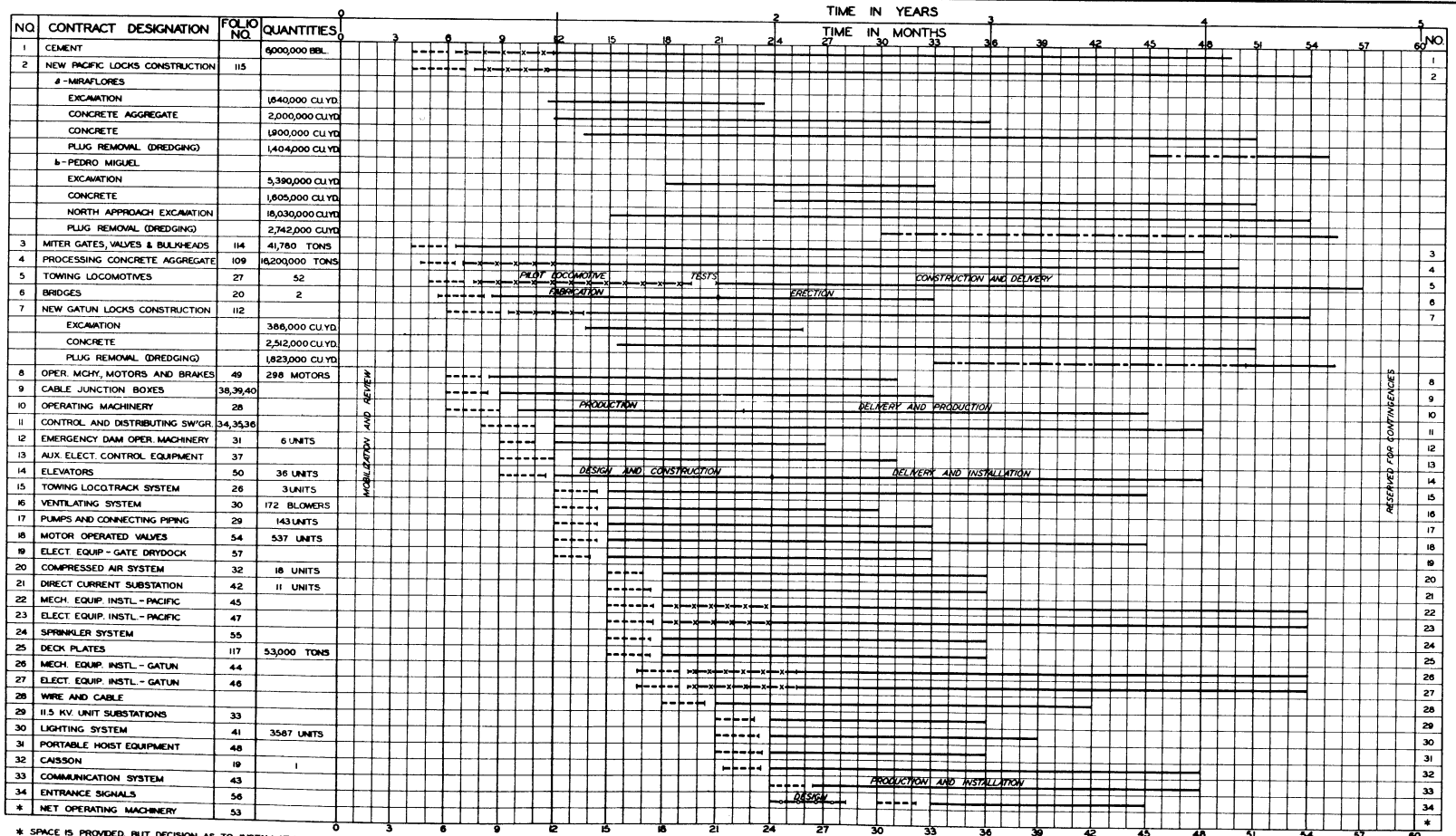
Operations and Schedules

196. Figure 21 shows a schedule of operations based upon a five-year period of construction. The schedule shown contemplates the immediate availability of qualified key personnel. If the mobilization of such a group is required, the early phases of construction may be delayed several months.

197. Probable rates for performing certain major features of the work are shown in Figure 22. For comparison, the rates encountered on the excavation and dredging performed to date are shown also.

198. Unwatering Excavated Sites. The Miraflores and Gatun Locks areas have been flooded to minimize the effect of weathering of the foundation materials. The unwatering of these areas prior to advertisement of the plans for bids will permit a reasonable estimate of the quantity of loose material to be removed and will furnish prospective bidders an opportunity for evaluating pumpage and foundation problems.

199. Cement. Arrangements had been made with the U. S. Maritime Commission in 1941 to furnish four ships of approximately 60,000-barrel capacity for transporting bulk cement from the United States to the contractors' docks at the sites. The ships were to have a speed of 10 knots and were estimated to require 22 days per round trip from Houston, Texas. The contractors were to unload the ships at a specified minimum rate and were to provide a specified minimum storage. The supply of cement will



NO.	CONTRACT DESIGNATION	FOLIO NO.	QUANTITIES
1	CEMENT		6,000,000 BBL.
2	NEW PACIFIC LOCKS CONSTRUCTION	115	
	a - MIRAFLORES		
	EXCAVATION		1,640,000 CU.YD.
	CONCRETE AGGREGATE		2,000,000 CU.YD.
	CONCRETE		1,900,000 CU.YD.
	PLUG REMOVAL (DREDGING)		1,404,000 CU.YD.
	b - PEDRO MIGUEL		
	EXCAVATION		5,390,000 CU.YD.
	CONCRETE		1,605,000 CU.YD.
	NORTH APPROACH EXCAVATION		18,030,000 CU.YD.
	PLUG REMOVAL (DREDGING)		2,742,000 CU.YD.
3	MITER GATES, VALVES & BULKHEADS	114	41,780 TONS
4	PROCESSING CONCRETE AGGREGATE	109	16,200,000 TONS
5	TOWING LOCOMOTIVES	27	52
6	BRIDGES	20	2
7	NEW GATUN LOCKS CONSTRUCTION	112	
	EXCAVATION		386,000 CU.YD.
	CONCRETE		2,512,000 CU.YD.
	PLUG REMOVAL (DREDGING)		1,823,000 CU.YD.
8	OPER. MCHY., MOTORS AND BRAKES	49	298 MOTORS
9	CABLE JUNCTION BOXES	38,39,40	
10	OPERATING MACHINERY	28	
11	CONTROL AND DISTRIBUTING SW'GR.	34,35,36	
12	EMERGENCY DAM OPER. MACHINERY	31	6 UNITS
13	AUX. ELECT. CONTROL EQUIPMENT	37	
14	ELEVATORS	50	36 UNITS
15	TOWING LOCO.TRACK SYSTEM	26	3 UNITS
16	VENTILATING SYSTEM	30	172 BLOWERS
17	PUMPS AND CONNECTING PIPING	29	143 UNITS
18	MOTOR OPERATED VALVES	54	537 UNITS
19	ELECT. EQUIP - GATE DRYDOCK	57	
20	COMPRESSED AIR SYSTEM	32	18 UNITS
21	DIRECT CURRENT SUBSTATION	42	11 UNITS
22	MECH. EQUIP. INSTL. - PACIFIC	45	
23	ELECT. EQUIP. INSTL. - PACIFIC	47	
24	SPRINKLER SYSTEM	55	
25	DECK PLATES	117	53,000 TONS
26	MECH. EQUIP. INSTL. - GATUN	44	
27	ELECT. EQUIP. INSTL. - GATUN	46	
28	WIRE AND CABLE		
29	11.5 KV. UNIT SUBSTATIONS	33	
30	LIGHTING SYSTEM	41	3587 UNITS
31	PORTABLE HOIST EQUIPMENT	48	
32	CAISSON	19	1
33	COMMUNICATION SYSTEM	43	
34	ENTRANCE SIGNALS	56	
*	NET OPERATING MACHINERY	53	

* SPACE IS PROVIDED, BUT DECISION AS TO INSTALLATION DEFERRED.

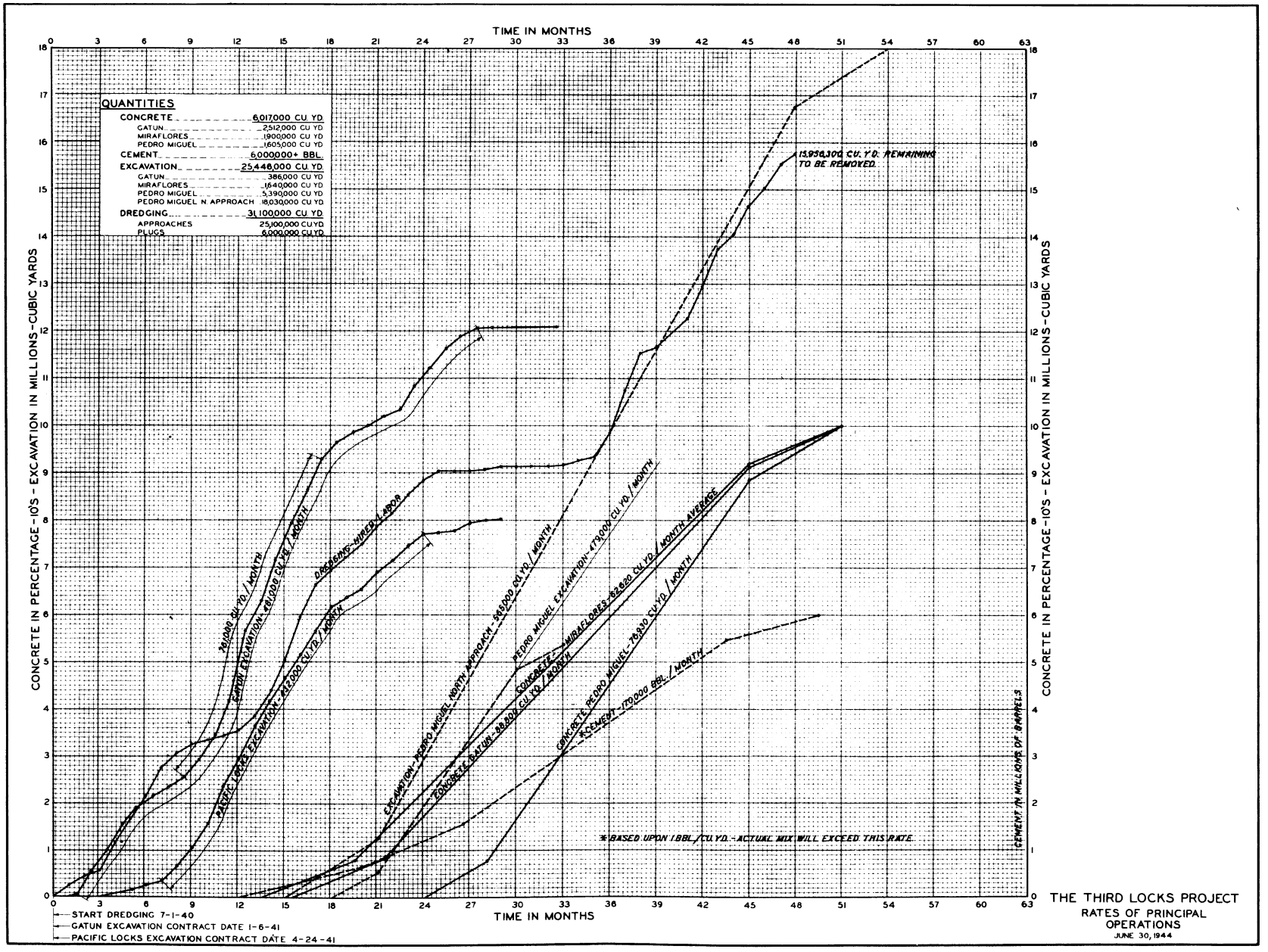
LEGEND:

ADVERTISEMENT AWARD MOBILIZATION PRODUCTION AND/OR DELIVERY

DREDGING OF MATERAL IN PLUGS SURPLUS TO DIKE REQUIREMENTS.

THE THIRD LOCKS PROJECT
SCHEDULE OF OPERATIONS
JUNE 30, 1944

FIGURE 21



THE THIRD LOCKS PROJECT
RATES OF PRINCIPAL OPERATIONS
JUNE 30, 1944

FIGURE 22

require close coordination of schedules for manufacture, transportation, and use. By virtue of a contract settlement, The Panama Canal now owns in Houston a bulk cement storage and ship-loading plant which may prove profitable for future use.

200. Concrete Aggregates. The existing facilities of The Panama Canal and the necessity for coordinating barge movements with other ship transits made it desirable for The Panama Canal to supply the raw Chagres aggregates by its dredges for processing and to deliver the aggregates by barge from both Gamboa and Miraflores as required. The use of the Chagres aggregate supply will require the transit of barges, tugs, and other equipment through the railroad and highway bridge at Gamboa which is now "fixed". Due to an excessive price on bid and to the time involved in making a movable span to transit barges and equipment, a plan was adopted for shuttling barges, either in water ballast or loaded, under the span. A part of the fender system for such operation has been placed. However, with a return to normalcy in the steel fabricating industry, it is probable that the adopted plan should be abandoned and the movable bridge plan restored. It is estimated that the movable bridge will not only provide greater safety and economy in operation of the barges but will facilitate the transit of other equipment which is now passed by the removal of an 80-foot fixed span.

201. The final processing of aggregates is planned for a contract operation. The plants required for such processing have been substantially completed under a previous contract. However, many important items such as shovels, power plant, and pumps; and minor parts such as screens, motors, and valves, have been released to others in the war effort and other items will be released in the future. As a consequence, a careful inventory will be required immediately prior to resumption. It is probable that the diesel power supply originally installed but later sold will not require replacement.

202. The transportation of aggregates will require a number of barges and tugs. In 1942, there were sixteen 1000-cubic-yard barges under construction for this service. This equipment was released to another war agency and it will have to be replaced. It is probable that the tugs now on hand, which were purchased for this service and for dredging, will be adequate.

203. Locks Construction. The major construction work has been divided between the Gatun Locks and the Pacific Locks. In the revision resulting from suspension of the work, the excavation for Pedro Miguel Lock and its north approach has been included in the work on the Pacific Locks. The rough processing of Miraflores basalt for concrete aggregate is also planned for the Pacific Locks contract, to permit coordination with the remaining Miraflores excavation. Otherwise, the plans are substantially as advertised in 1941 and 1942, except for minor corrections due to late developments and additions of more complete details. The

contracts are designed to give the contractors as great a latitude as practicable in planning, purchasing, and scheduling of operations and material supply. The items furnished by the Government are limited to cement, concrete aggregates, miter gates and valves, and certain deck (armor) plate. The work under each contract is divided into parts to permit the concurrent operations of installing machinery and electrical equipment. Figures 23 and 24 show the construction schedules originally adopted for the Gatun Locks and the Pacific Locks, respectively.

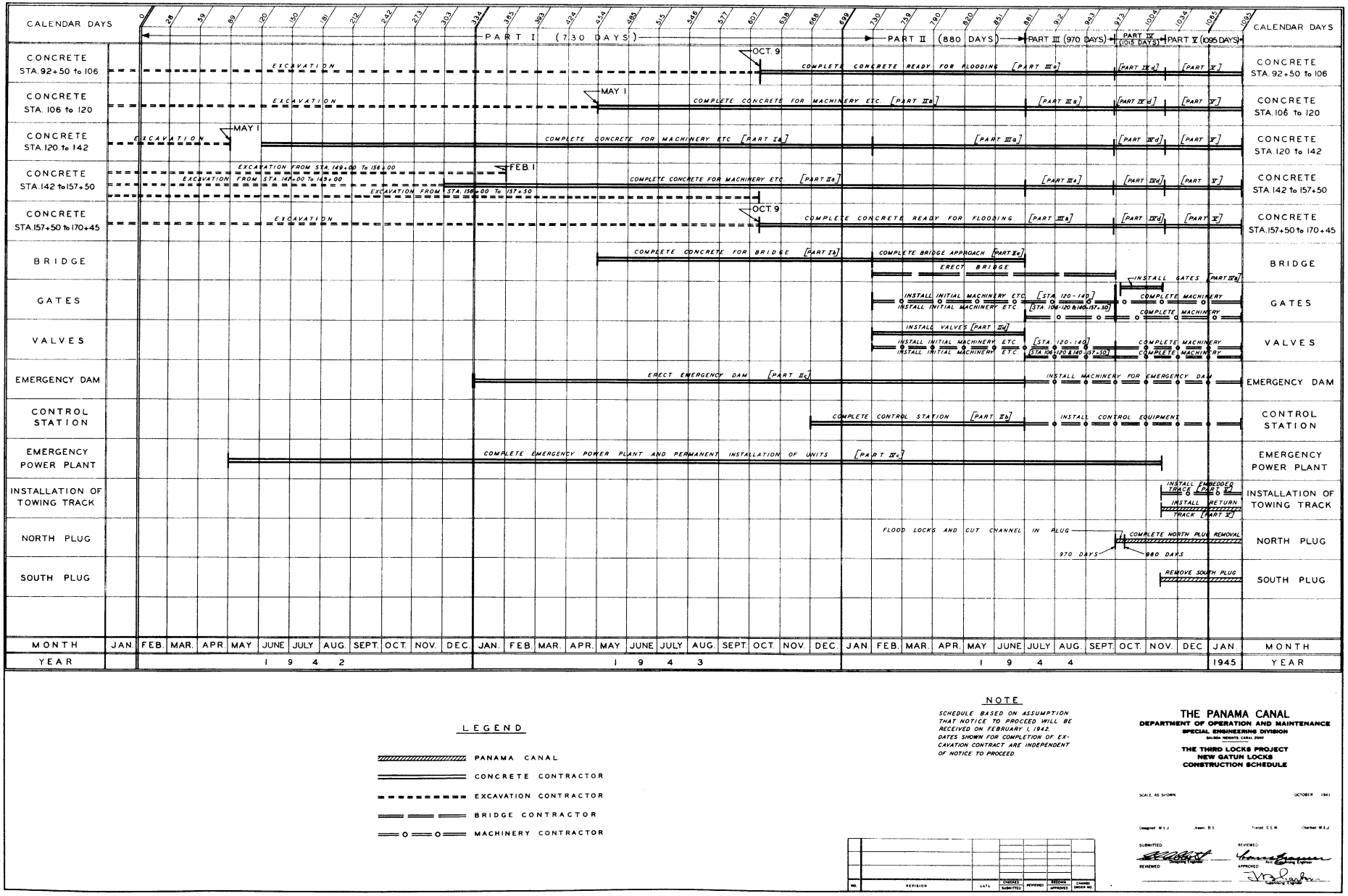
204. The contracts include the furnishing and erection of the emergency dams since they will have to be fabricated by welding in place. Large amounts of other plate work are involved, which may warrant the establishment of a moderate-sized plate-fabricating plant at the site.

205. Caisson, Miter Gates, Valves, and Bulkheads. These units are common to all locks and the installation by units is a minor operation. The contracts are arranged for their construction in the United States and delivery by the Government as required at the sites. Only one caisson will be obtained, and its use will be required for certain operations at all locks as they approach completion.

206. Bridges. A separate contract provides for the fabrication and field erection of the bridges for both Gatun and Miraflores Locks. The work is of a specialized character and limited equipment and space are required for erection. The combining of the two bridges in one contract was to provide an economical construction operation, both in fabrication and erection.

207. Equipment Procurement. The procurement of equipment and its delivery on schedule will be a major operation for the construction organization. Contracts have been planned to include materials common to all locks and that may be produced by one manufacturer. In some cases the quantities involved may tax the normal capacity of certain plants and a division of awards may be required. Correlations must be maintained between certain contracts to insure proper functioning of the equipment. Due to the relatively remote location of the work, shop inspection should be particularly thorough to avoid excessive delays and costs caused by defects being revealed after delivery. Economies may be expected by acceptance at the plant of items whose character will permit such action. The contracts should be clear in this respect to avoid the inclusion of heavy contingencies in manufacturers' prices. The extent to which such practices may be followed and the amount of benefits obtained will depend largely upon the organization conducting these operations.

208. Mechanical and Electrical Installations. The installation of equipment is tentatively planned to be divided between electrical and mechanical at Gatun Locks and at the Pacific Locks, making four major contracts. The furnishing and installation of elevators and communications at all locks have been planned as separate contracts. The basis for the



LEGEND

- PANAMA CANAL
- CONCRETE CONTRACTOR
- EXCAVATION CONTRACTOR
- BRIDGE CONTRACTOR
- MACHINERY CONTRACTOR

NOTE

SCHEDULE BASED ON ASSUMPTION THAT NOTICE TO PROCEED WILL BE RECEIVED ON FEBRUARY 1, 1942. DATES SHOWN FOR COMPLETION OF EXCAVATION CONTRACT ARE INDEPENDENT OF NOTICE TO PROCEED

NO.	REVISION	DATE	CHECKED SUBMITTED	REVIEWED	RECOMM. APPROVED	CHANGE ORDER NO.

THE PANAMA CANAL
DEPARTMENT OF OPERATION AND MAINTENANCE
SPECIAL ENGINEERING DIVISION
BALBOA HEIGHTS, CANAL ZONE

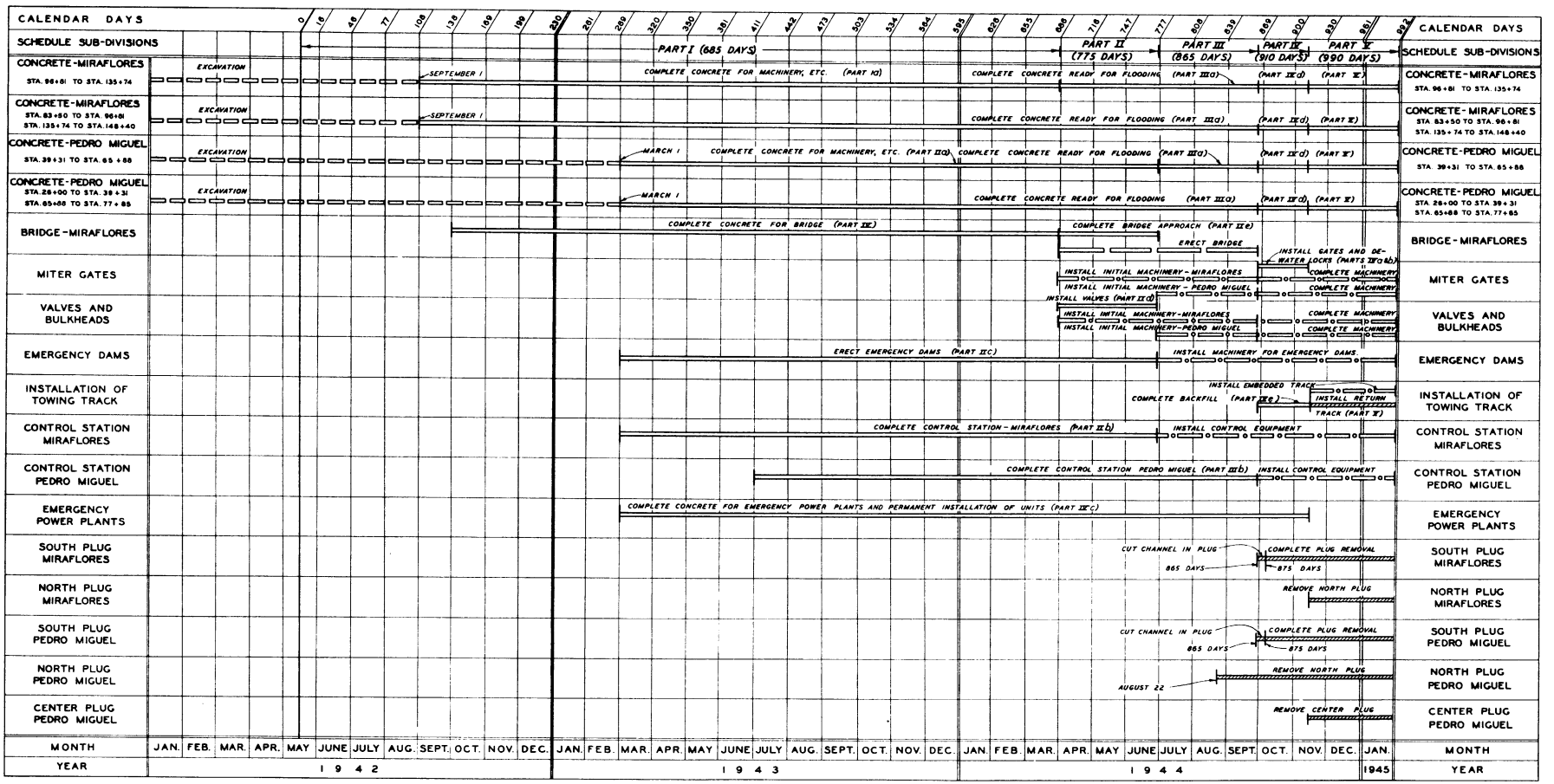
THE THIRD LOCKS PROJECT
NEW GATUN LOCKS
CONSTRUCTION SCHEDULE

SCALE AS SHOWN — OCTOBER 1941

Designed W.E.J. Drawn D.S. Traced C.E.W. Checked W.E.J.

SUBMITTED: Designing Engineer
REVIEWED: Asst. Designing Engineer
REVIEWED:
APPROVED: Supervising Engineer

FIGURE 23



LEGEND:

- PANAMA CANAL
- CONCRETE CONTRACTOR
- EXCAVATION CONTRACTOR
- BRIDGE CONTRACTOR
- MACHINERY CONTRACTOR

NOTE:

SCHEDULE BASED ON ASSUMPTION THAT NOTICE TO PROCEED WILL BE RECEIVED ON MAY 15TH. 1942. DATES SHOWN FOR COMPLETION OF EXCAVATION CONTRACT ARE INDEPENDENT OF NOTICE TO PROCEED.

NO.	REVISION	DATE	CHECKED SUBMITTED	REVIEWED	RECOMM APPROVED	CHANGE ORDER NO.

THE PANAMA CANAL
DEPARTMENT OF OPERATION AND MAINTENANCE
SPECIAL ENGINEERING DIVISION
BALBOA HEIGHTS CANAL ZONE

THE THIRD LOCKS PROJECT
NEW MIRAFLORES LOCKS - MASONRY
GENERAL
CONSTRUCTION SCHEDULE

SCALE NONE — FEBRUARY 1942

Designed W.E.J. — Drawn B.S. — Traced W.S.O. — Checked J.F.M.

SUBMITTED — REVIEWED — APPROVED

FIGURE 24

divisions was to keep the size of the contracts within a competitive range of price and in accord with the natural character of the work. The work lends itself readily to such divisions, but close cooperation must be maintained to avoid conflicts in working areas. A survey of potential contractors at the time of resumption may show that it would be advantageous to combine in one contract the electrical and mechanical work at each site or the work at both sites.

209. Dredging. The approach channels to all locks, except the large one north of new Pedro Miguel Lock, are being dredged by hired-labor and Government plant in accordance with the original plan developed in 1940. Estimates prepared at that time showed that substantial savings would be effected by removing the north approach to Pedro Miguel in the dry by modern excavation equipment. Experience with that type of equipment on Gatun and Miraflores Locks excavation has verified that conclusion. The plan also provides that the removal of the dikes (plugs), which must be done in the wet near completion of the work, will be done with this force. The plugs as now planned contain large volumes of material over the section required for stability as a dike. Some of this surplus is required for highway and railroad services and also as a safeguard against breaching by explosives. Most of this surplus can be removed upon completion of the bridges to reduce the rate of removal required on completion of the lock structures. Consideration should be given under the locks contracts to the removal of such surpluses in the dry. There is also a quantity of carbonaceous muck on the east bank of the Gatun north approach to be dredged after removal of the north plug.

210. Construction Drawings. A large amount of equipment, details of which will depend on the manufacturer, is to be placed in the lock walls. The size and character of the structure does not permit full development of details on the contract plans. Accordingly, construction specifications provide that "monolith" and "lift" drawings will be furnished by the Government as the work progresses. These drawings will also include the reinforcing steel details which are shown typically in the contract drawings. It was planned that the monolith drawings with all recesses, anchor layouts, and steel details would be prepared in the Diablo Heights Office. Each Area Office was to prepare lift sketches from these drawings and was to permit the contractor to show on them such construction detail as desired.

211. Relocations. All facilities to be relocated for the Gatun Locks have been reconstructed except a railroad station for the new relocated section of the Panama Railroad and the locks crossing of the 44-kv transmission line. The plans contemplate that the contractor will construct a dock in Gatun Lake adjacent to the Stilson's Pond area for unloading construction materials. Large quantities of various materials will require handling over the existing railroad tracks. Substantial interferences with both the railroad and construction operations may occur if this line were maintained in regular service. It is, therefore, probable that the new station should be constructed soon after resumption of work and that the main-line railroad traffic should be diverted over its permanent relocated line.

212. A temporary overhead line that now serves for a power connection should be replaced by a permanent gas-filled cable as soon as the locks crossover is completed.

213. On the Pacific Locks, the road and electrical utilities now crossing the intermediate basalt plug of new Miraflores Locks will have to be temporarily relocated across the north plug. When the locks crossover and the new bridge are completed, these facilities can be placed in their permanent positions. Certain cable installations now in the Pedro Miguel area may have served their purpose and may have been removed prior to resumption of work; otherwise, they will have to be relocated. Certain cables serving navigation aids will require attention.

214. Organization. A possible organization for construction by contract, exclusive of administrative and procurement personnel, is shown in Figure 25. In addition to those shown, it is probable that about 100 engineers and draftsmen will be required for coordination of equipment details with and for the preparation of the monolith drawings. This number is included in the 250 shown later for the Diablo Heights Office. This group would also provide a staff of well-qualified technical personnel for consultation on all problems that will arise as the work progresses. An organization of comparable size may be required in the United States to procure the equipment in conformity with the specifications, required functions, and delivery schedules.

Personnel and Living Facilities

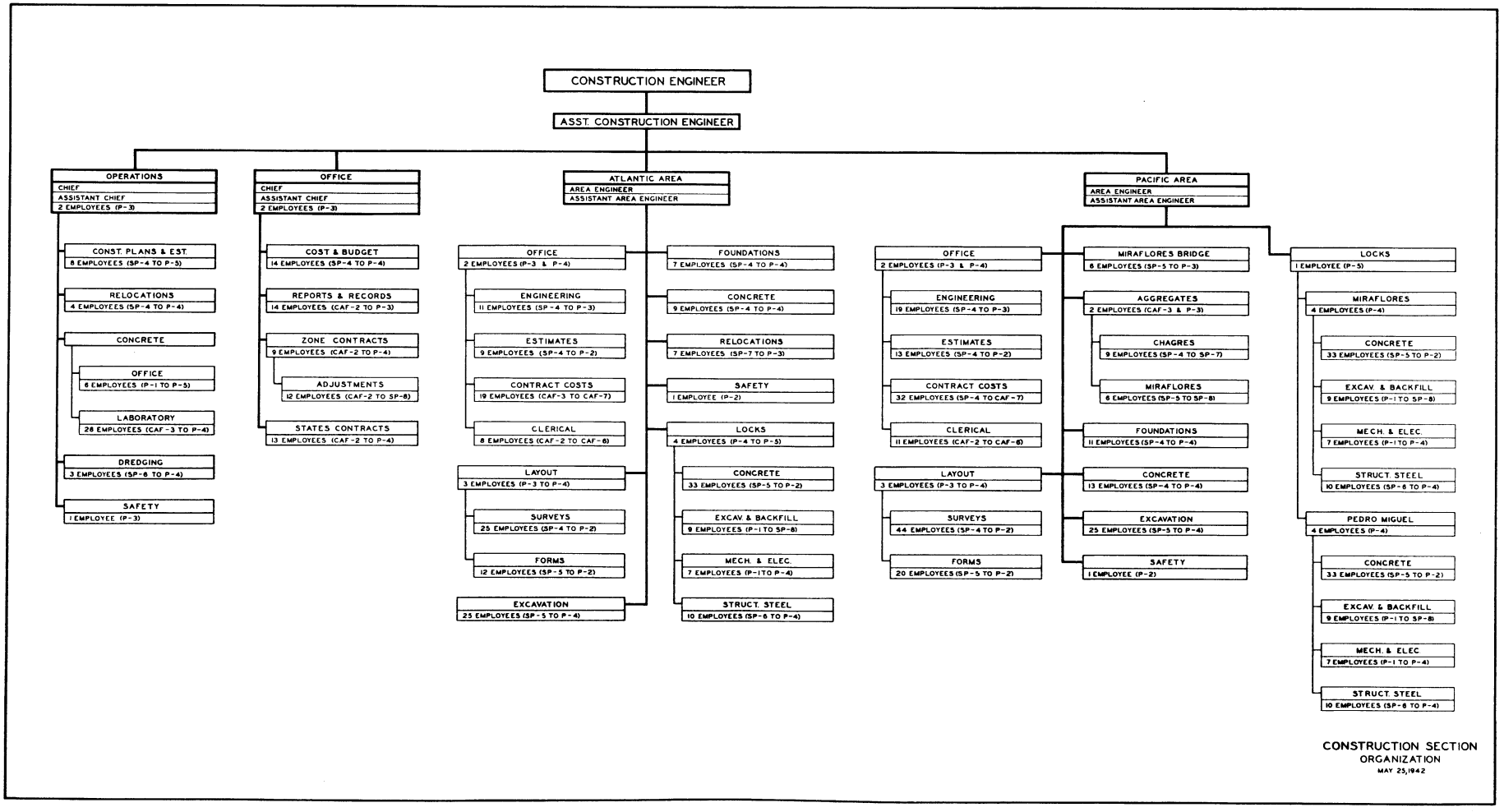
215. The personnel requirements of the Government, exclusive of civil, supply, and medical requirements, have been estimated as follows:

	Gold	Silver
Diablo Heights Office	250	30
Atlantic Area Office	165	25
Pacific Area Office	244	30
Gamboa	8	2

From previous experience, it is estimated that 75 per cent of these employees will be married and will require family quarters.

216. The personnel requirements for contractors' forces have been estimated as follows:

	Gold	Silver
Gatun Locks	1200	1900
Pacific Locks	2400	3300
Gamboa	60	30



CONSTRUCTION SECTION
ORGANIZATION
MAY 25,1942

FIGURE 25

Obviously, these estimates are susceptible to wide variations dependent on the degree of mechanization employed by the contractors and on other factors. It is estimated that less than 75 per cent of this group will require family quarters. The peak of employment may be attained about 1-1/2 years after start of operations.

217. The quarters available for occupation upon resumption of work are shown in Paragraph 173. In addition to this housing, certain Panama Canal facilities may be available from those constructed with other funds and maintained at the expense of Third Locks funds during the interim between lay-up and resumption. As previously mentioned, the possible use of surplus housing constructed by the Army and Navy should be investigated.

218. The gold quarters shown are not adequate for both Government and contractors' forces. Areas have been allocated for development by the contractor as his needs occur. Some of the existing quarters should be allocated for the contractor's initial needs while he is completing his housing. Due to the long period required for delivery of construction materials, the locks construction specifications provide that building materials to complete a certain number of quarters will be held for optional use of the contractor at tariff rates for a period of 6 months. The quarters shown for "Silver," with such others that now appear available, will probably be adequate.

219. Commissaries, schools, and dispensaries are located in each of the Third Locks towns and are operated by the appropriate Divisions of The Panama Canal. Gymnasiums connected with the schools furnish recreation for adults out of school hours and space for large social functions. Other common civil functions such as post offices, police and fire departments, municipal services, garbage disposal, and maintenance of grounds on certain houses and buildings are similarly provided. Clubhouses furnish limited restaurant and fountain service, bowling alleys, billiards, moving pictures, and space for social functions. Except for restaurant services, all these facilities are estimated to be adequate for the construction period.

220. The plan contemplates that the two major locks contractors will operate restaurant or mess facilities for their own employees. It will probably be desirable to extend these services, by a suitable contract clause, to a maximum number of employees of other contractors, possibly at a stipulated price or at direct cost plus a fixed percentage. A small building is available for a gold restaurant at Cocoli. Completely equipped facilities are available for silver messes at Cocoli Silver and Gatun Silver.

APPENDIX A

LIST OF MAJOR EQUIPMENT
Contract No. PClp-571

Martin Wunderlich Company and
Okes Construction Company

Number	Size	Item
5	3-1/2 cu.yd.	Shovels with Dragline attachments, Diesel
1	3-1/2 cu.yd.	Shovel, Diesel
1	3/4 cu.yd.	Shovel with Dragline attachment
1	5 tons	Truck Crane
50	12 cu.yd.	Dump Trucks, Diesel
2	18 cu.yd.	Euclid Semi-Trailer Bottom-Dump Trucks
23	RD-8	Caterpillar Tractors, Diesel
11		Dozer Blade Attachments
3		Push-Dozer Attachments
3	25 cu.yd.	Carrimor Scrapers
3	14 cu.yd.	Carrimor Scrapers
2		Rooters
2		Rotary Drills, Truck Mounted
3	315 cfm.	Air Compressors, Diesel, Portable
1	105 cfm.	Air Compressor, Gas, Portable
4	#12	Auto Patrol Graders, Diesel
1	#77	Fabick Road Grader
2	1500 gal.	Sprinkler Trucks
1	1500 gal.	Fuel Truck
1	5 tons	Grease Truck with 105 cfm. air
9	1-1/2 tons	Stake-Body Trucks
1	1 ton	Stake-Body Truck
3	3/4 ton	Pickup Trucks
11	1-1/2 tons	Pickup Trucks
6	300-400 amp.	Electric Welders
6	1500 w.	Light Plants
1	50 kw.	Light Plant
1	85 kw.	Light Plant

Miscellaneous equipment such as jackhammers, pumps, and machine shop tools. The list is as of August 31, 1942.
In addition to the above equipment, a 22-inch hydraulic dredge was used to remove about 2,000,000 cubic yards under a subcontract.

APPENDIX B

LIST OF MAJOR EQUIPMENT
Contract No. PC1p-602

Panama Constructors, Inc.

Number	Size	Item
5	5 cu.yd.	Shovels (2 with Dragline Attachments), Electric
2	2-1/2 cu.yd.	Shovels with Dragline Attachments, Diesel
1	3/4 cu.yd.	Shovel, Diesel
1	2 cu.yd.	Dragline, Steam
1	12 cu.yd.	Monighan Dragline with 8-cu.yd. Attachment and Boom
2	15 tons	Truck Cranes
1	3/8 cu.yd.	Shovel, Gas
40	20 cu.yd.	Dump Trucks, Gas
2	20 cu.yd.	Dump Trucks, Gas
10	10 cu.yd.	Dump Trucks, Gas
3	6 cu.yd.	Dump Trucks, Gas
2	1-1/2 cu.yd.	Dump Trucks, Gas
6	21 cu.yd.	Tournapulls, Diesel
6	15-19 cu.yd.	Carrimor-Scrapers
1		Rooter
17	RD-8	Caterpillar Tractors, Diesel
1	RD-4	Caterpillar Tractor, Diesel
18		Dozer Blade Attachments
1	FD-8	Tread Dozer
2	1500 cfm.	Compressors, Diesel
5	750 cfm.	Compressors, Diesel
6	400 cfm.	Compressors, Diesel
1	9 by 8 in.	Compressor, Electric
3	8-3/8 by 4-3/4 by 5	Compressors, Diesel
1	10-1/4 by 17 by 12	Compressor, Electric
18	9 in.	Blast-hole Drills, Diesel, Crawler
2	9 in.	Blast-hole Drills, Electric, Crawler
28		Wagon Drills
3	#12	Auto Patrol Graders, Diesel
1	10 tons	Road Roller, Gas
1	15 tons	Road Roller, Gas
2	5 tons	Flat-Bed Trucks (one with Air and Tire Hoist Equipment)
1	2000 gal.	Tank Truck
1	1-1/2 tons	Flat-Bed Truck
13	1-1/2 tons	Stake-Body Trucks

APPENDIX B
(Continued)

26	1/2 ton	Pickup Trucks
5	200-600 amp.	Electric Welders
15	3-20 kw.	Light Plants
2	1-1/2 kw.	Light Plants
1		Large Rock-Crusher Plant Assembly
14	150 hp.	Diesel Engines for Crusher Plant and Pumps

Miscellaneous equipment, such as jackhammers, pumps, flood lights, and extensive repair shop for motorized equipment and sharpening equipment for drill steel. The list is as of August 31, 1942.

APPENDIX C

SUMMARY OF COSTS AND CONTRACT PRICES
MODIFIED CONSTRUCTION PROGRAM
June 30, 1944

CONTENTS

APPENDIX C

CONTENTS
(continued)

APPENDIX C

SUMMARY OF COSTS AND CONTRACT PRICES
MODIFIED CONSTRUCTION PROGRAM
June 30, 1944

Item	Unit	Unit Cost or Price	Quantity	Amount
NEW GATUN LOCKS				
Design				$1,877,583.89
Relocation of Buildings, Structures and Utilities				
Navigation Aids				3,285.59
Streets, Roads, and Walks				116,113.73
Water Lines				44,133.93
Sewer Lines				63,123.51
Power Lines				583,976.70
Communication Systems				61,593.76
Gas Lines				3,029.70
Extension to Guardhouse				3,726.92
Mindi Dock				245,259.19
Miscellaneous Structures				17,432.75
Water Storage Tanks and Systems				332,977.69
Abandoned Highway Bridge				46,096.51
Drainage Culvert Stilson's Pond				18,576.58
Supervision and Inspection				13,323.13
Overhead				59,980.00
Total, Relocations				$1,612,629.69
Relocation, Fort Davis				
Construction				$ 756,480.93
Reimbursement, Army				(256,111.80)
Reimbursement, Post Exchange				(45,405.82)
Total, Fort Davis				$ 454,963.31
Wet Excavation, By-Pass Channels				
Clearing and Grubbing	acre	$ 407.52	117	$ 47,970.25
Wash Borings	lin.ft.	1.13	6,921	7,831.52
Hydraulic Dredging	cu.yd.	0.157	5,430,000	825,002.52
Dipper Dredging	cu.yd.	0.393	2,271,700	868,670.25
Subaqueous Mining	cu.yd.	0.834	407,500	332,534.36
Shore Mining	cu.yd.	0.26	1,224,100	292,114.52
Surveys				66,098.31
Supervision and Inspection				5,217.89
Overhead				94,467.00
Total, Wet Excavation				$2,539,906.62

Item	Unit	Unit Cost or Price	Quantity	Amount
Excavation, Locks Structure, South Approach Channel and Appurtenant Works, Contract PC1p-571				
Contract Prices				
Excavation, Class "A"	cu.yd.	$ 0.70	5,796,547	$4,057,582.90
Excavation, Class "B"	cu.yd.	0.70	6,321,955	4,425,368.50
Excavation, Class "C"	cu.yd.	1.40	1,184,980	1,658,972.00
Drilling 2-in. Test Holes	lin.ft.	1.00	311.5	311.50
Grading Unclassified for Railroad Relocation	cu.yd.	0.90	597,902	538,111.80
Excavation Unclassified for Drainage Canal	cu.yd.	0.90	125,960	113,364.00
Install 12-in. C.I. Culvert Pipe, Stock	lin.ft.	1.50	226	339.00
Install 24-in. C.I. Culvert Pipe, Stock	lin.ft.	1.50	321	481.50
Install 24-in. Concrete Culvert Pipe, Stock	lin.ft.	1.25	250	312.50
Install 30-in. Concrete Culvert Pipe, Stock	lin.ft.	1.50	171	256.50
Install 30-in. Concrete Culvert Pipe, 7-1/2-in. Shell	lin.ft.	2.80	1,077	3,015.60
Install 36-in. Concrete Culvert Pipe, 5-in. Shell	lin.ft.	3.80	498	1,892.40
Install 36-in. Concrete Culvert Pipe, 8-in. Shell	lin.ft.	4.30	588	2,528.40
Concrete	cu.yd.	20.00	1,208.3	24,166.00
Concrete Footings	cu.yd.	35.00	1,339.9	46,896.50
Drilling Holes in Overburden	lin.ft.	1.00	3,898	3,898.00
Blasting	lb.	0.50	2,792	1,396.00
Excavation, Unclassified, Power House	cu.yd.	0.90	9,775	8,797.50
Protective Fencing	lin.ft.	0.90	3,368	3,031.20
Construction Timber Towers	lump sum			1,430.00
Filling Spoil Area #1	lump sum			5,500.00
Subtotal				$10,897,651.80
Price Adjustment, Labor				117,576.64
Price Adjustment, Materials				44,450.48
Price Adjustment, Freight				5,520.79
Subtotal, Price Adjustment				$ 167,547.91

Item	Unit	Unit Cost or Price	Quantity	Amount
Contract Deductions				
Excess Excavation, Concrete				$ (1,504.00)
Excess Excavation, Earth				(1,259.25)
Services Furnished by Government				(3,110.17)
Corrective Measures (Dredging Spoil)				(13,408.75)
Deleted Work				(6,000.00)
Subtotal, Deductions				$ (25,282.17)
Net Contract Price				$11,039,917.54
Government Costs				
Site Clearing				$ 7,364.71
Slope Determination Core Borings				39,053.17
Slope Protection				8,058.22
Furnishing Power Facilities				13,757.06
Differential for Silver Mess				6,153.70
Furnish Culvert Pipe				2,328.75
Furnish Cement				6,422.38
Furnish Aggregate				7,546.45
Furnish Reinforcing Steel				37,197.40
Miscellaneous Charges for Garbage, Health, Road Maintenance				36,458.29
Surveys				247,596.30
Supervision and Inspection				240,926.82
Overhead				451,692.00
Subtotal, Government Costs				$1,104,555.25
Total, Contract PClp-571				$12,144,472.79
Railroad Relocations				
Trackwork				$ 315,152.23
Culverts				44,033.96
Supervision and Inspection				282.11
Overhead				13,886.00
Total, Railroad Relocations				$ 373,354.30
Locks Structure and Appurtenant Work, Contract PClp-659				
Contract Prices				
Excavation	cu.yd.	$ 8.00	350,000	$2,800,000.00
Foundation Preparation	sq.ft.	0.20	3,030,000	606,000.00
Drilling 2-1/2-in. Test Holes	lin.ft.	0.70	78,000	54,600.00
Drilling 2-in. Core Holes	lin.ft.	2.50	5,000	12,500.00
Drilling 8-in. Concrete Cores	lin.ft.	6.00	1,000	6,000.00
Pressure Grouting	cu.ft.	1.50	5,000	7,500.00

Item	Unit	Unit Cost or Price	Quantity	Amount
Contract Prices (Continued)				
Backfill, Impervious	cu.yd.	$ 0.50	120,000	$ 60,000.00
Backfill, Pervious	cu.yd.	0.30	2,550,000	765,000.00
Gravel Drain	cu.yd.	2.50	16,000	40,000.00
Concrete Below Operating Level	cu.yd.	8.00	1,330,000	10,640,000.00
Concrete Above Operating Level	cu.yd.	7.70	722,000	5,559,400.00
Concrete in Upper Approach Walls	cu.yd.	7.00	90,000	630,000.00
Concrete in Lower Approach Walls	cu.yd.	7.00	145,000	1,015,000.00
Concrete in Floors and Sills	cu.yd.	7.50	190,000	1,425,000.00
Concrete in Extension Slab	cu.yd.	7.00	70,000	490,000.00
Concrete in Central Control Station	cu.yd.	30.00	3,000	90,000.00
Concrete, Miscellaneous	cu.yd.	25.00	5,000	125,000.00
Concrete Piles	lin.ft.	5.00	8,600	43,000.00
Concrete Pipe, 18-in.	lin.ft.	6.90	1,300	8,970.00
Concrete Pipe, 24-in.	lin.ft.	12.00	6,000	72,000.00
Concrete Pipe, 30-in.	lin.ft.	15.00	3,200	48,000.00
Concrete Pipe, 36-in.	lin.ft.	19.90	500	9,950.00
Concrete Pipe, 48-in.	lin.ft.	40.00	1,800	72,000.00
Precast Concrete Gutter	lin.ft.	3.00	28,700	86,100.00
Unloading Bulk Cement	bbl.	0.10	2,800,000	280,000.00
Unloading Aggregate	ton	0.20	4,470,000	894,000.00
Timber	Mbm.	400.00	320	128,000.00
Steel, Reinforcing	lb.	0.06	89,600,000	5,376,000.00
Steel, Structural	lb.	0.22	23,500,000	5,170,000.00
Steel, Alloy	lb.	0.20	1,097,000	219,400.00
Steel, Castings	lb.	0.30	5,755,000	1,726,500.00
Steel, Forgings	lb.	0.70	45,000	31,500.00
Iron Castings	lb.	0.30	3,597,000	1,079,100.00
Bronze	lb.	0.80	37,200	29,760.00
Copper Waterstops	lb.	0.90	211,500	190,350.00
Copper Wire and Plates	lb.	0.90	60,000	54,000.00
Brass	lb.	1.00	102,400	102,400.00
Babbitt	lb.	0.90	80,600	72,540.00
Lead	lb.	0.50	47,400	23,700.00
Stair Treads	lin.ft.	5.50	6,300	34,650.00
Steel Stairs	lb.	0.40	305,000	122,000.00
Handrail	lb.	0.50	68,500	34,250.00
Pipe, Cast Iron	lb.	0.20	393,000	78,600.00
Pipe, Steel	lb.	0.20	1,171,000	234,200.00
Pipe, Wrought Iron	lb.	0.40	224,900	89,960.00
Pipe Valves	lb.	0.70	31,800	22,260.00
Conduit, Rigid Metal	lb.	0.60	1,002,000	601,200.00
Conduit, Fiber	lin.ft.	0.60	600	360.00
Corrugated Steel Plate	lb.	0.15	2,368,000	355,200.00
Fence	lin.ft.	5.00	15,100	75,500.00
Highway Guard Rail	lin.ft.	3.00	1,000	3,000.00

Item	Unit	Unit Cost or Price	Quantity	Amount
Contract Prices (Continued)				
Emergency Dam, Deck Plate on Dam	lb.	$ 0.20	7,069,000	$ 1,413,800.00
Emergency Dam, Deck Plate on Sill, Installation	ton	47.00	4,100	192,700.00
Emergency Dam, Structural Steel	lb.	0.20	4,285,000	857,000.00
Emergency Dam, Cast Steel	lb.	0.30	1,110,000	333,000.00
Emergency Dam, Forgings	lb.	0.15	842,400	126,360.00
Emergency Dam, Copper-Nickel Alloy and Brass	lb.	0.30	19,100	5,730.00
Emergency Dam, Rubber	lb.	1.00	22,600	22,600.00
Emergency Dam, Roller Bearings	lb.	2.00	59,000	118,000.00
Deck Plate, Installation	ton	40.00	16,000	640,000.00
Miter Gates, Installation	ton	10.00	12,200	122,000.00
Lock Valves, Tainter, Installation	lb.	0.04	800,000	32,000.00
Lock Valves, Vertical Rising, Installation	lb.	0.04	1,214,000	48,560.00
Emergency Power Units, Installation	ea.	45,000.00	3	135,000.00
Emergency Power Plant, Auxiliaries, Installation	lump sum			100,000.00
Central Control Station, Miscellaneous	lump sum			300,000.00
Service Plumbing	lump sum			73,400.00
Floor Tile	sq.ft.	3.00	5,200	15,600.00
Wall Tile	sq.ft.	3.00	6,600	19,800.00
Subtotal				$46,250,000.00
Waiver of Bond Premium				(545,000.00)
Net Total Contract Price PClp-659				$45,705,000.00*
Contract Termination				$1,506,811.96
Government Costs				
Contractors Expense Assumed by Special Engineering Division				$ 2,260.70
Supervision and Inspection				2,696.86
Overhead				49,027.00
Subtotal				$ 53,984.56
Sale of Equipment Acquired by Termination				$ (242,611.54)
Total, Contract PClp-659				$1,318,184.98
Total, New Gatun Locks				$20,321,095.58

Item	Unit	Unit Cost or Price	Quantity	Amount
NEW PEDRO MIGUEL LOCK				
Design				$1,254,448.88
Wet Excavation, By-Pass Channel				
Wash Borings	lin.ft.	$ 2.33	452	$ 1,056.13
Hydraulic Dredging	cu.yd.	0.206	377,600	77,739.66
Subaqueous Mining	cu.yd.	0.516	141,600	73,076.97
Surveys				4,567.21
Supervision and Inspection				3,322.73
Overhead				6,172.00
Total, Wet Excavation				$ 165,934.70
Excavation, Lock Structure, Approach Channel and Appurtenant Works				
Government Costs				$ 96,407.60
Core Borings				12,314.80
Clearing and Grubbing				32,990.04
Surveys				10,261.27
Supervision and Inspection				23,220.00
Overhead				$ 175,193.71
Subtotal				
Contractor's earnings are included under Contract PC1p-602 for Miraflores Locks Excavation for presentation of entire contract under one heading				
Total, New Pedro Miguel Lock				$1,595,577.29
NEW MIRAFLORES LOCKS				
Design				$1,658,018.69
Relocations, Structures and Utilities				
Navigation Aids				$ 13,209.37
Streets, Walks, Roads				207,434.50
Water Lines				87,072.41
Sewer Lines				2,779.02
Power Lines				19,814.62
Communication Systems				27,834.95

Item	Unit	Unit Cost or Price	Quantity	Amount
Relocations, Structures and Utilities (Continued)				
Supervision and Inspection				$ 866.80
Overhead				13,869.00
Total, Relocations				$ 372,880.67
Wet Excavation, By-Pass Channel				
Clearing and Grubbing	acre	$42.55	204.3	$ 8,693.33
Wash Borings	lin.ft.	1.26	12,748	16,150.61
Hydraulic Dredging	cu.yd.	0.31	2,232,000	671,585.72
Dipper Dredging	cu.yd.	0.61	5,599,900	3,427,284.53
Subaqueous Mining	cu.yd.	1.32	1,279,900	1,687,152.05
Shore Mining	cu.yd.	0.60	1,920,400	1,160,460.47
Surveys				90,144.71
Supervision and Inspection				6,044.57
Overhead				273,018.00
Total, Wet Excavation				$7,340,533.99
Excavation, Locks Structures, Approach Channels, and Appurtenant Works for Pedro Miguel and Miraflores Locks, Contract PClp-602				
Contract Prices				
Excavation, Class "A"	cu.yd.	$ 0.55	12,342,000	$6,788,100.00
Excavation, Class "B"	cu.yd.	0.79	15,602,000	12,325,580.00
Stock-piling Rock for Concrete Aggregate	cu.yd.	1.00	2,150,000	2,150,000.00
Drilling 2-in. Test Holes	lin.ft.	1.00	30,000	30,000.00
Exploratory Drifts	cu.yd.	30.00	2,500	75,000.00
Grading, Unclassified, for Railroad and Highway Construction	cu.yd.	1.00	690,000	690,000.00
Grading, Unclassified, for Diversion Channels	cu.yd.	1.00	66,500	66,500.00
Excavation for Structures	cu.yd.	15.00	14,200	213,000.00
Concrete, Class "A"	cu.yd.	25.00	1,920	48,000.00
Concrete, Class "B"	cu.yd.	20.00	900	18,000.00
Reinforcing Steel	lb.	0.06	400,000	24,000.00
Embedding Railroad Rails	lump sum			1,000.00
Wrought-Iron Pipe Handrail	lin.ft.	4.50	452	2,034.00
Concrete Pipe Culvert	lin.ft.	7.00	696	4,872.00
Total, Contract Prices				$22,436,086.00

Item	Unit	Unit Cost or Price	Quantity	Amount
Revised Prices (Result of Modification) (A, for Work Prior to May 31, 1942) (B, Subsequent to May 31, 1942)				
Excavation, Class "A"				
A-1	cu.yd.	$ 0.37	1,712,651	$ 633,680.87
B-1	cu.yd.	0.44	1,577,483	694,092.52
Excavation, Class "B"				
A-2	cu.yd.	0.95	1,943,364	1,846,195.80
B-2	cu.yd.	1.45	2,768,585	4,014,448.25
Stock-piling Rock for Concrete Aggregate				
A-3	cu.yd.	1.12	94,134	105,430.08
B-3a	cu.yd.	0.75	44,170	33,127.50
B-3b	cu.yd.	0.40	120,604	48,241.60
Drilling 2-in. Test Holes				
A-4	lin.ft.	0.80	144	115.20
Grading, Unclassified, for Railroad and Highway Construction				
A-6	cu.yd.	0.26	365,022	94,905.72
B-6	cu.yd.	1.18	306,926	362,172.68
Excavation, Unclassified, for Diversion Channels				
A-7	cu.yd.	0.46	39,849	18,330.54
B-7	cu.yd.	0.45	3,494	1,572.30
Excavation for Structure				
A-8	cu.yd.	1.78	9,869.76	17,568.17
B-8	cu.yd.	18.65	1,562.76	29,145.47
Concrete, Class "A"				
A-9	cu.yd.	63.85	1,212.45	77,414.93
B-9	cu.yd.	43.89	931.97	40,904.16
Concrete, Class "B"				
A-10	cu.yd.	29.70	970.66	28,828.60
Reinforcing Steel				
A-11	lb.	0.13	300,262	39,034.06
B-11	lb.	0.096	175,878	16,884.29
Embedding Railroad Rails				
A-12	lump sum			333.00
B-12	lump sum			208.00
Wrought-Iron Pipe Handrail				
B-13	lin.ft.	1.89	452	854.28
Concrete Pipe Culvert, 12-in.				
A-14	lin.ft.	5.52	106	585.12
B-14	lin.ft.	5.30	408	2,162.40
C.I. Pipe Culvert, 12-in.				
B-15	lin.ft.	5.68	72	408.96

Item	Unit	Unit Cost or Price	Quantity	Amount
Revised Prices (Result of Modification) (A, for Work Prior to May 31, 1942) (B, Subsequent to May 31, 1942) (Continued)				
Furnishing and Installing Precast Concrete Gutter B-16	lin.ft.	$ 1.93	3,054	$ 5,894.22
Riprap, Grouted B-17	cu.yd.	8.36	92.68	774.80
Excavation, Unclassified, for Emergency Power Plant B-20	cu.yd.	0.97	26,508	25,712.76
Line Drilling for Emergency Power Plant B-21	lin.ft.	0.45	4,815	2,166.75
Mixing Concrete for Emergency Power Plant B-22	hr.	30.00	385.50	11,565.00
Furnishing Crawler Crane Services B-23	hr.	9.00	757.50	6,817.50
Furnishing Truck Crane Services B-24	hr.	5.00	278.75	1,616.75
Ditch Excavation, Pedro Miguel B-25	cu.yd.	1.50	3,277	4,915.50
Filling Low Areas, Pedro Miguel B-26	cu.yd.	0.44	14,336	6,307.84
Furnishing 10-cu.yd. Dump Truck Services B-27	hr.	5.60	123.5	691.60
Furnishing 20-cu.yd. Dump Truck Services B-28	hr.	7.00	67.5	472.50
Excavation, Drainage Structure, Vicinity Station 133+50 B-29	cu.yd.	2.00	247.5	495.00
Grouted Riprap Drainage Structure, Vicinity Station 133+50 B-30	cu.yd.	19.55	29.85	583.57
Precast Concrete Slab on Structure, Vicinity Station 133+50 B-31	lin.ft.	3.36	491.50	1,651.44
Emergency Work on Slide Highway Station 65+50 B-32	lump sum			590.59

Item	Unit	Unit Cost or Price	Quantity	Amount
Revised Prices (Result of Modification) (A, for Work Prior to May 31, 1942) (B, Subsequent to May 31, 1942) (Continued)				
Fill for Storage Areas B-33	lump sum			$ 448.37
Temporary Protective Fencing B-34	lin.ft.	0.90	1,130	1,017.00
Install 16-in. and 30-in. Pipe Drains B-35	lump sum			230.12
Preparation of Equipment for Shipment and Storage B-36	lump sum			33,812.43
Purchase of Plant and Equipment				5,421,554.12
Price Adjustment, Labor				42,430.68
Price Adjustment, Supplies				26,622.78
Purchase of Spare Parts, Small Tools, Material and Supplies				283,405.47
Change Order No. 8, (Supplement No. 1, 2b)				1,238.33
Lump Sum Credit, Change Order No. 6, Paragraph 2a (3)				(30,763.52)
Lump Sum Credit, Change Order No. 6, Paragraph 2b (2)				(930.00)
Lump Sum Credit, Change Order No. 8, Paragraph 2h				(13,490.80)
Services Furnished by the Government (Supplemental Agreement No. 3)				(11,952.05)
Refund of Bond Premium (Supplemental Agreement No. 2)				(138,046.12)
Subtotal, Revised Prices				$13,792,477.13
Government Costs				
Clearing				$ 10,909.08
Core Borings for Slope Determination				23,425.86
Power Facilities				30,079.28
Differential for Silver Mess				9,890.28
Miscellaneous Charges for Garbage, Health, Road Maintenance				14,573.89
Surveys				201,888.01
Supervision and Inspection				200,125.80
Overhead				430,385.39
Subtotal, Government Costs				$ 921,277.59

Item	Unit	Unit Cost or Price	Quantity	Amount
Sale and Rental of Equipment and Supplies Acquired from Contractor				$(1,888,234.18)
Sale of Crushed Rock				$ (118,757.77)
Total Cost, Excavation Locks Structures, Approach Channels, and Appurtenant Works for Pedro Miguel and Miraflores Locks				$12,706,762.77
Lock Structure and Appurtenant Works Quotation by Low Bidder: Panama Constructors, Inc.				
Bid Prices				
Excavation, Miraflores	cu.yd.	$ 5.00	185,000	$ 925,000.00
Excavation, Pedro Miguel	cu.yd.	4.75	195,000	926,250.00
Excavation, Caissons	cu.yd.	30.00	2,800	84,000.00
Excavation, Piers	cu.yd.	7.50	28,300	212,250.00
Excavation, Tunnel	cu.yd.	18.50	1,700	31,450.00
Shale Protection	sq.ft.	0.25	225,500	56,375.00
Foundation Preparation	sq.ft.	0.25	3,700,000	925,000.00
Drilling 1-1/2-in. Grout Holes, 25 ft. and less in Depth	lin.ft.	1.50	10,800	16,200.00
Drilling 1-1/2-in. Grout Holes over 25 ft. in Depth	lin.ft.	3.50	9,200	32,200.00
Drilling 2-in. Core Holes	lin.ft.	3.75	7,000	26,250.00
Drilling 2-1/2-in. Anchor Bar and Weep Holes	lin.ft.	1.50	79,000	118,500.00
Drilling 8-in. Anchor Bar Holes	lin.ft.	10.00	110	1,100.00
Drilling 8-in. Concrete Cores	lin.ft.	10.00	1,500	15,000.00
Pressure Grouting, Connections	ea.	5.00	650	3,250.00
Pressure Grouting	cu.ft.	1.50	20,000	30,000.00
Backfill, Impervious	cu.yd.	0.75	152,200	114,150.00
Backfill, Pervious	cu.yd.	0.65	2,857,700	1,857,505.00
Derrick Stone	cu.yd.	3.50	129,100	451,850.00
Riprap, Grouted	cu.yd.	5.00	3,800	19,000.00
Gravel Drains	cu.yd.	1.85	1,900	3,515.00
Concrete Below Operating Level, Miraflores	cu.yd.	12.25#	1,022,700	12,528,075.00
Concrete Below Operating Level, Pedro Miguel	cu.yd.	12.20#	814,400	9,935,680.00
Concrete Above Operating Level, Miraflores	cu.yd.	12.45#	556,600	6,929,670.00
Concrete Above Operating Level, Pedro Miguel	cu.yd.	12.45#	421,600	5,248,920.00
Concrete in Approach Walls, Miraflores	cu.yd.	13.25#	187,100	2,479,075.00

Unit price fixed at $11.00 by negotiation.

Item	Unit	Unit Cost or Price	Quantity	Amount
Bid Prices (Continued)				
Concrete in Approach Walls, Pedro Miguel	cu.yd.	$ 12.60#	295,300	$3,720,780.00
Concrete in Floors and Sills, Miraflores	cu.yd.	12.80#	127,500	1,632,000.00
Concrete in Floors and Sills, Pedro Miguel	cu.yd.	12.65#	115,700	1,463,605.00
Concrete in Central Control Station, Miraflores	cu.yd.	40.00	3,900	156,000.00
Concrete in Central Control Station, Pedro Miguel	cu.yd.	40.00	2,700	108,000.00
Concrete, Caissons, Piers, and Tunnel	cu.yd.	14.50	19,350	280,575.00
Concrete, Miscellaneous, Miraflores	cu.yd.	50.00	3,120	156,000.00
Concrete, Miscellaneous, Pedro Miguel	cu.yd.	50.00	3,200	160,000.00
Concrete Piles	lin.ft.	7.50	5,800	43,500.00
Concrete Pipe, 18-in.	lin.ft.	12.50	2,480	31,000.00
Concrete Pipe, 24-in.	lin.ft.	15.00	3,030	45,450.00
Concrete Pipe, 30-in.	lin.ft.	30.00	4,710	141,300.00
Concrete Pipe, 36-in.	lin.ft.	50.00	220	11,000.00
Concrete Pipe, 48-in.	lin.ft.	40.00	1,560	62,400.00
Precast Concrete Gutter	lin.ft.	3.50	26,330	92,155.00
Unloading Bulk Cement	bbl.	0.25	3,875,000	968,750.00
Unloading Aggregate	ton	0.45	4,575,000	2,058,750.00
Timber	Mbm.	250.00	550	137,500.00
Steel, Reinforcing	lb.	0.065	123,536,000	8,029,840.00
Steel, Structural	lb.	0.15	31,054,500	4,658,175.00
Steel, Alloy	lb.	0.35	1,266,800	443,380.00
Steel, Castings	lb.	0.29	8,948,600	2,595,094.00
Steel, Forgings	lb.	0.50	304,200	152,100.00
Iron Castings	lb.	0.20	5,424,700	1,084,940.00
Bronze	lb.	1.00	42,100	42,100.00
Copper Waterstops	lb.	1.00	253,000	253,000.00
Copper Wire, Plates, Inserts, and Bars	lb.	0.94	101,000	94,940.00
Brass	lb.	1.32	104,000	137,280.00
Babbitt	lb.	0.75	141,500	106,125.0
Lead	lb.	0.60	68,500	41,100.0
Stair Treads	lin.ft.	1.50	7,750	11,625.0
Steel Stairs	lb.	0.25	455,200	113,800.0
Handrail	lb.	0.30	140,200	42,060.0
Pipe, Cast Iron	lb.	0.25	687,400	171,850.0
Pipe, Steel	lb.	0.25	2,263,200	565,800.0
Pipe, Wrought Iron	lb.	0.25	273,800	68,450.0

Unit price fixed at $11.00 by negotiation.

Item	Unit	Unit Cost or Price	Quantity	Amount
Bid Prices (Continued)				
Pipe, Valves	lb.	$ 2.00	50,500	$ 101,000.00
Conduit	lb.	0.30	1,800,000	540,000.00
Corrugated Steel Plate	lb.	0.13	3,963,900	511,797.00
Fence	lin.ft.	2.75	15,800	43,450.00
Highway Guard Rail	lin.ft.	10.00	175	1,750.00
Emergency Dam, Deck Plate on Dam	lb.	0.10	13,102,000	1,310,200.00
Emergency Dam, Deck Plate on Sill, Installation	ton	60.00	7,100	426,000.00
Emergency Dam, Structural Steel	lb.	0.17	7,831,000	1,331,270.00
Emergency Dam, Cast Steel	lb.	0.40	3,278,900	1,311,560.00
Emergency Dam, Forgings	lb.	0.60	1,428,500	857,100.00
Emergency Dam, Copper-Nickel Alloy and Brass	lb.	1.00	88,500	88,500.00
Emergency Dam, Rubber	lb.	5.00	41,750	208,750.00
Emergency Dam, Roller Bearings	lb.	1.50	143,100	214,650.00
Deck Plate, Installation	ton	60.00	23,510	1,410,600.00
Miter Gates, Installation	ton	35.00	17,010	595,350.00
Lock Valves, Tainter, Installation	lb.	0.04	4,830,600	193,224.00
Lock Valves, Vertical Rising, Installation	lb.	0.03	1,792,000	53,760.00
Emergency Power Units, Installation, Miraflores	ea.	30,000.00	2	60,000.00
Emergency Power Units, Installation, Pedro Miguel	ea.	30,000.00	2	60,000.00
Emergency Power Plant, Auxiliaries, Installation, Miraflores	lump sum			20,000.00
Emergency Power Plant, Auxiliaries, Installation, Pedro Miguel	lump sum			20,000.00
Frequency Changer, Installation, Miraflores	lump sum			10,500.00
Frequency Changer, Installation, Pedro Miguel	lump sum			10,500.00
Central Control Station, Miscellaneous, Miraflores	lump sum			300,000.00#
Central Control Station, Miscellaneous, Pedro Miguel	lump sum			200,000.00
Service Plumbing, Miraflores	lump sum			30,000.00
Service Plumbing, Pedro Miguel	lump sum			25,000.00
Floor Tile	sq.ft.	3.50	26,400	92,400.00
Wall Tile	sq.ft.	3.75	27,900	104,625.00
Subtotal				$82,982,675.00

Lump sum fixed at $287,905 by negotiation.

Item	Unit	Unit Cost or Price	Quantity	Amount
Negotiated Reduction (Distributed as noted)				$5,000,000.00
Net Contract Price				$77,982,675.00*
Bridge Over Existing Miraflores Locks, Swing Spans and East Approach Viaduct Superstructure, PClp-583				
Contract Prices				
Structural Steel, Approach Viaduct	lb.	$ 0.097	5,088,795	$ 493,613.12
Structural Steel, Movable Bridge	lb.	0.118	2,523,501	297,773.12
Roadway Grating	sq.ft.	2.50	12,650	31,625.00
Sidewalk Grating	sq.ft.	1.60	2,060	3,296.00
Machinery	lb.	0.47	439,621	206,621.87
Signal and Traffic Control System	lump sum			17,675.00
Counterweights and Adjustments	lump sum			2,272.58
Counterweight Punchings	lb.	0.059	60,000	3,540.00
Electrical Equipment	lump sum			60,061.00
Patterns and Core Boxes	lump sum			2,140.00
Mixing Paint	lump sum			151.80
Subtotal, Contract Price				$1,118,769.49
Freight Adjustment				7,982.54
Subtotal, Contract Price				$1,126,752.03
Bridge Over Existing Miraflores Locks, Substructure and Appurtenant Works				
Government Costs				
Clear and Grub	acre	$426.00	8.5	$ 3,621.03
Excavation	cu.yd.	7.30	19,377	141,518.54
Embankment, East	cu.yd.	0.62	60,100	37,451.44
Compacted Backfill	cu.yd.	1.54	9,508	14,611.69
Common Backfill	cu.yd.	1.02	10,128	10,295.26
Cast and Drive Concrete Piling	ea.	252.52	1,120	282,817.04
Riprap	sq.yd.	2.32	68	157.72
Concrete, Class "A"	cu.yd.	48.59	11,052	537,035.88
Reinforcing Steel	lb.	0.058	843,549	48,536.16
Anchor Bolts	lb.	0.32	17,870	5,665.96
Steel Windows and Doors	ea.	84.03	20	1,680.67
Miscellaneous Metal Work	lb.	0.20	20,400	3,980.39
Concrete, Drains	lin.ft.	6.77	450	3,048.12
Tile Roof	sq.ft.	1.38	600	827.08
Plumbing	lump sum			3,038.87

Item	Unit	Unit Cost or Price	Quantity	Amount
Government Costs (Continued)				
Protection, Existing Water and Oil Lines	lump sum			$ 8,180.88
Wig-Wag Signal	lump sum			704.49
Widen Highway Intersection	lump sum			8,058.64
Railroad Track Crossing Highway	lump sum			990.38
Grade Crossing Signals and Gates	lump sum			2,900.75
Furnish Ready Mixed Concrete	lump sum			4,483.89
Stairway Tower	lump sum			10,265.82
Chain Link Fence	lump sum			5,199.90
Steel Cover Plates, Mud Guards	lump sum			5,451.25
Approach Pavement, East Embankment	sq.yd.	$ 3.91	1,101	4,308.12
Bridge Roadway	sq.yd.	12.74	5,023	63,974.41
Fire Line	lump sum			5,711.76
Railing and Miscellaneous Structural	lump sum			2,846.22
Repaving Approach, East Embankment	lump sum			6,792.96
West Embankment, Roadway Paving	lump sum			3,267.88
Trackwork	lump sum			24,666.09
Electrical Installations	lump sum			64,662.30
Miscellaneous Work	lump sum			13,737.85
Surveys				8,516.56
Supervision and Inspection				55,147.19
Overhead				97,382.00
Subtotal, Government Costs				$1,491,535.19
Total, Miraflores Bridge				$2,618,287.22
Railroad Construction				$ 25,858.25
Total, New Miraflores Locks				$24,722,341.59
GENERAL				
Furnish Emergency Power Plants Contract PClp-653				
Contract Prices				
Diesel Engine Generating Units Complete with Accessories	ea.	207,613.87	7	$1,453,297.09
Three-Unit Plant Auxiliaries	ea.		1	47,370.64
Two-Unit Plant Auxiliaries	ea.	36,443.70	2	72,887.40
Spare Parts	lump sum			55,868.24
Replacement Parts	lump sum			71,487.77
Additional Data	lump sum			700.75
Subtotal				$1,701,611.89

Item	Unit	Unit Cost or Price	Quantity	Amount
Price Adjustment, Materials and Labor				$ 97,994.60
Services of Erecting Engineer				18,035.00
Subtotal				$ 116,029.60
Deductions				
Liquidated Damages				$ (600.00)
Work Deletion				(285.00)
Subtotal				$ (885.00)
Net Contract Price				$1,816,756.49
Government Costs				
Freight				$ 68,737.34
Supervision and Inspection				32,909.48
Overhead				74,108.00
Subtotal, Government Costs				$ 175,754.82
Total, Contract PClp-653				$1,992,511.31
Furnish Frequency Changers Contract PClp-673				
Contract Prices				
6000-kw Frequency Changer, Plant "G"	ea.		1	$ 157,382.00
6000-kw Frequency Changer, Plant "M"	ea.		1	166,731.00
3000-kw Frequency Changer, Plant "M"	ea.		1	106,879.00
Spare Parts	lump sum			31,237.00
Grounding Reactor	ea.		1	436.00
Subtotal				$ 462,665.00
Services, Erecting Engineer				$ 665.00
Subtotal, Contract Price				$ 463,330.00
Government Costs				
Freight				$ 14,167.50
Supervision and Inspection				3,996.28
Overhead				18,600.00
Subtotal, Government Costs				$ 36,763.78
Total, Contract PClp-673				$ 500,093.78

Item	Unit	Unit Cost or Price	Quantity	Amount
Temporary Construction Power Plant, Gatun				
Construct Building and Facilities				$ 294,317.63
Install Mechanical Equipment, Contract PClp-737				78,528.75
Install Electrical Equipment, Contract PClp-779				26,437.90
Materials Furnished by Government				356,749.49
Performance Tests				18,753.59
Fuel Oil Truck				5,100.00
Excavation for Structure				8,797.50*
Storage and Delivery of Equipment				37,550.34
Supervision and Inspection				70,669.58
Overhead				33,528.00
Subtotal, Gatun Plant				$ 921,635.28
Temporary Construction Power Plant, Miraflores				
Construct Building and Facilities				$ 347,771.91
Install Mechanical Equipment, Contract PClp-737				105,295.73
Install Electrical Equipment, Contract PClp-779				46,398.22
Materials Furnished by Government				454,399.56
Performance Tests				23,951.47
Fuel Oil Truck				4,000.00
Mixing Concrete				11,565.00*
Excavation for Structure				27,879.51*
Storage and Delivery of Equipment				36,798.85
Supervision and Inspection				105,150.82
Overhead				44,190.00
Subtotal, Miraflores Plant				$1,167,956.56
Total, Emergency Power Plants in Temporary Locations				$4,582,196.93
Furnish Miter Gates, Valves, and Bulkheads, Contract PClp-671				
Contract Prices				
Miter Gates, Steel Structural	lb.	0.1544	50,811,000	$7,845,218.40
Miter Gates, Steel Castings	lb.	0.20	10,587,000	2,117,400.00
Miter Gates, Steel Forgings	lb.	0.70	565,000	395,500.00
Miter Gates, Copper-Nickel-Brass	lb.	2.00	212,000	424,000.00
Miter Gates, Rubber	lb.	1.50	35,000	52,500.00
Miter Gates, Steel Pipe	lb.	0.50	483,000	241,500.00

Item	Unit	Unit Cost or Price	Quantity	Amount
Contract Prices (Continued)				
Miter Gates, Pipe Valves	lb.	$ 1.00	242,000	$ 242,000.00
Miter Gates, Lead	lb.	0.30	141,000	42,300.00
Miter Gates, Babbitt	lb.	0.70	213,000	149,100.00
Miter Gates, Bridge, Structural Steel	lb.	0.20	349,000	69,800.00
Valve and Bulkhead, Structural Steel	lb.	0.20	6,886,000	1,377,200.00
Valve and Bulkhead, Steel Castings	lb.	0.43	4,551,000	1,956,930.00
Valve and Bulkhead, Steel Forgings	lb.	0.70	20,000	14,000.00
Valve and Bulkhead, Copper-Nickel-Brass	lb.	2.00	523,000	1,046,000.00
Valve and Bulkhead, Rubber	lb.	1.50	22,700	34,050.00
Subtotal, Contract Prices				$16,007,498.40
Credit for Waiver of Bond				$ (16,000.00)
Net Contract Price				$15,991,498.40*
Termination Costs				
Reimbursement for Expenditures				$ 67,969.26
Government Costs				
Inland Freight				$ 13.61
Overhead				2,626.00
Subtotal, Government Costs				$ 2,639.61
Total, Contract PClp-671				$ 70,608.87
Processing Concrete Aggregate Contract PClp-623				
Contract Prices				
Processing Chagres River Aggregate	ton	$ 0.48	9,000,000	$4,320,000.00
Loading Chagres River Aggregate	ton	0.09	7,200,000	648,000.00
Processing Stock-piled Rock, Miraflores	ton	0.70	2,500,000	1,750,000.00
Loading Miraflores Aggregate	ton	0.22	740,000	162,800.00
Subtotal, Contract Prices				$6,880,800.00*
Termination Costs				$2,443,943.33
Government Costs				
Investigations, Design, Specifications				$ 29,257.80
Alterations, Gamboa Bridge				9,449.70

Item	Unit	Unit Cost or Price	Quantity	Amount
Government Costs (Continued)				
Fender System and Dewatering Dock				$ 95,206.18
Access Road				41,740.24
Furnish Electric Power Facilities				30,189.02
Dredging Overburden	cu.yd.	$ 0.09	2,236,700	203,139.53
Contractor's Expense Assumed by Special Engineering Division				9,404.02
Store Plant for Stand-By				21,636.69
Supervision and Inspection				49,754.49
Overhead				79,595.00
Subtotal, Government Costs				$ 569,372.67
Sale of Equipment and Materials Acquired from Contractor				$ (873,278.56)
Total, Contract PClp-623				$2,140,037.44
Stock-piling Rock, Concrete Aggregate, Contract Price PClp-602	cu.yd.	$ 1.00	2,150,000	$2,150,000.00*
Termination Costs				
Stock-pile Rock	cu.yd.	1.12	94,134	$ 105,430.08
Stock-pile Rock	cu.yd.	0.75	44,170	33,127.50
Stock-pile Rock	cu.yd.	0.40	120,604	48,241.60
Subtotal, Contract PClp-602				$ 186,799.18**
Unloading Concrete Aggregates Contract Price (Miraflores)				$2,058,750.00*
Unloading Concrete Aggregates Contract Price PClp-659 (Gatun)	ton	0.20	4,470,000	$ 894,000.00*
Chagres Aggregate (Raw) Supply and Storage (Was to be done by Government Plant) Estimate				$1,392,000.00*
Transportation of Aggregates (Was to be done by Government Plant) Estimate				$1,500,000.00*
Total, Processing Concrete Aggregate				$2,140,037.44

	Unit	Unit Cost or Price	Quantity	Amount
Furnish Cement, Contracts PClp-624 and PClp-625				
Contract Prices				
Furnish Cement, PClp-624	bbl.	$ 1.35	4,000,000	$5,400,000.00
Furnish Cement, PClp-625	bbl.	1.395	2,790,000	2,790,000.00
Subtotal, Contract Prices				$8,190,000.00
Termination Costs				
Reimbursement of Expenditures, PClp-624				$ 168,150.06
Reimbursement of Expenditures, PClp-625				629,686.59
Subtotal, Termination Costs				$ 797,836.65
Unload Cement, Contract Price PClp-659, Gatun	bbl.	$ 0.10	2,800,000	$ 280,000.00
Unload Cement, Bid Price (Miraflores)	bbl.	$ 0.25	3,875,000	$ 968,750.00
Transportation Cement (Was to have been done by Maritime Commission)	bbl.	$ 0.50	6,790,000	$3,395,000.00
Government Costs				
Sale of Equipment				$ (5,321.3
Supervision and Inspection				599.4
Overhead				30,638.0
Subtotal, Government Costs				$ 25,916.1
Total, Furnish Cement				$ 823,752.8
Total, General				$7,616,596.0
TOWNSITES				
Margarita (Gold)				
Type 102 Cottage (1)	ea.	$13,663.67	5	$ 68,318.3
Type 103 Apartment Building (2)	ea.		1	15,794.6
Type 104 Apartment Building (2)	ea.		1	21,792.9
Type 201 Apartment Building (12)	ea.	43,558.93	3	130,676.7
Type 215 Apartment Building (4)	ea.	17,784.25	13	231,195.3
Type 217 Apartment Building (4)	ea.	23,559.97	13	306,279.7
Type 218 Apartment Building (2)	ea.	17,880.85	7	125,165.9

Item	Unit	Unit Cost or Price	Quantity	Amount
Margarita (Gold) (Continued)				
40-Room Bachelor Building	ea.	$44,764.24	6	$ 268,585.46
Shoe and Tailor Shop				12,411.57
Post Office and Equipment				67,703.27
Install Air Compressor				186.60
Police Station				16,514.00
Fire Station				11,436.11
Clubhouse				348,423.12
Commissary				59,363.99
Hospital and Equipment				524,639.03
Nurses' Quarters				57,087.12
School				118,744.38
Gymnasium				115,088.36
Playgrounds (Equipment, Tennis Courts, Soft Ball, Bleachers)				56,319.91
Site Preparation (Grading, Landscaping)				274,870.58
Roads and Parking Areas				237,583.72
Water Lines				67,814.08
Sewer Lines				127,713.04
Power and Light System				198,606.50
Telephone System				30,320.36
Street Lights				21,599.34
Fire-Alarm System				2,407.88
Paving Under Quarters				3,717.90
Mapping Townsite				1,898.16
Supervision and Inspection				16,809.82
Overhead				137,878.00
Total, Margarita (Gold)				$3,676,946.09
Gatun (Silver)				
288/432-Man Barracks	ea.	$28,343.83	7	198,074.91
Post Office				20,156.04
Bunk Boiler				9,227.99
Dispensary				25,308.55
Playshed and Playgrounds				24,999.96
Silver Clubhouse				6,436.89
Preparation of Site				4,906.98
Roads, Streets, and Walks				9,179.06
Water Lines				748.70
Sewer Lines				4,128.55
Power and Lighting System				1,348.81
Street Lighting System				689.27
Fire-Alarm System				350.31
Supervision and Inspection				1,212.96
Overhead				11,850.00
Total, Gatun (Silver)				$ 318,618.98

Item	Unit	Unit Cost or Price	Quantity	Amount
Cocoli (Gold)				
Type 102 Cottage (1)	ea.	$13,427.15	2	$ 26,854.30
Type 201 Apartment Building (12)	ea.	38,538.01	2	77,076.01
Type 215 Apartment Building (4)	ea.	17,482.21	19	332,161.98
Type 217 Apartment Building (4)	ea.	23,910.90	10	239,108.97
Type 218 Apartment Building (2)	ea.	16,599.76	4	66,399.04
40-Room Bachelor Quarters	ea.	50,139.16	2	100,553.50
Post Office				52,346.66
Supply Department Building and Gas Station				53,643.60
Garage for Official Equipment				38,117.04
Police Station				18,772.88
Fire Station				18,240.79
Clubhouse, Equipment and Alterations				228,244.90
Commissary				52,288.35
Dispensary				42,950.83
Health Department Field Office				7,887.99
School				64,984.76
Gymnasium				98,024.69
Playgrounds (Tennis Court, Soft Ball Bleachers)				17,159.39
Preparation of Site and Landscaping				176,809.25
Roads, Streets, Walks, and Parking Area				175,294.33
Water Lines				98,589.68
Sewer Lines				104,064.31
Power Lighting System				95,971.42
Telephone System				26,711.21
Street Lighting System				5,226.58
Fire-Alarm System				1,924.05
Townsite Mapping				3,117.55
Salvage and other Miscellaneous Credits				(910.00
Supervision and Inspection				9,028.83
Overhead				86,170.00
Total, Cocoli (Gold)				$2,316,812.89
Cocoli (Gold) (Contract Quarters)				
Type 102 Cottage (1)	ea.	$12,699.69	3	$ 38,099.07
Type 215 Apartment Building (4)	ea.	20,724.43	16	331,650.91
Type 217 Apartment Building (4)	ea.	22,705.13	7	158,935.96
Type 218 Apartment Building (2)	ea.	13,951.32	7	97,659.24
40-Room Bachelor Building	ea.	46,273.26	2	92,546.52
Miscellaneous				10,467.25
Surveys, Plans, and Specifications				1,972.46
Supervision and Inspection				17,086.06
Overhead				28,911.00
Total, Cocoli (Gold)(Contract Quarters)				$ 777,328.47

Item	Unit	Unit Cost or Price	Quantity	Amount
Cocoli Contractors' Buildings Acquired under Contract PClp-602				
Type 215 Apartment Building (4)	ea.	$13,925.34	13	$ 181,029.47
Type 217 Apartment Building (4)	ea.	18,110.60	14	253,548.50
Type 218 Apartment Building (2)	ea.	10,707.54	9	96,367.91
Bachelor Barracks	ea.	42,586.04	3	127,758.14
Office Building			1	9,651.77
Chinese Quarters			1	3,205.44
Mess Hall				13,422.70
Utilities				36,885.23
Total, Contractors' Buildings				$ 721,869.16*
Cocoli (Silver)				
Type S-121	ea.	$ 9,869.56	2	$ 19,739.12
288/432-Man Barracks	ea.	32,162.59	4	128,650.29
Bunk Boiler				1,859.64
Mess Hall and Kitchen				104,894.71
Clubhouse (Design Charges)				3,689.11
Commissary				6,280.00
Playgrounds				9,242.80
Preparation of Site and Landscaping				17,304.11
Roads, Streets, Walks, and Parking Areas				26,191.25
Water Lines				9,377.13
Sewer Lines				17,875.85
Power and Lighting System				6,679.15
Telephone System				71.26
Street Lighting				1,550.81
Fire-Alarm System				16.85
Supervision and Inspection				3,210.27
Overhead				13,777.00
Total, Cocoli (Silver)				$ 370,409.35
Diablo Heights (Gold)				
Type 102 Cottage (1)	ea.	$ 8,676.70	8	$ 69,413.62
Type 103 Apartment Building (2)	ea.	13,636.72	4	54,546.89
Type 104 Apartment Building (2)	ea.	16,892.22	2	33,784.43
Type 201 Apartment Building (12)	ea.	34,343.37	6	206,060.20
Type 214 Apartment Building (4)	ea.	20,287.04	9	182,583.40
Type 215 Apartment Building (4)	ea.	16,827.04	22	370,209.98
Type 217 Apartment Building (4)	ea.	20,592.85	10	205,928.48
Type 218 Apartment Building (2)	ea.	15,644.57	2	31,289.13
40-Room Bachelor Building	ea.	39,981.50	3	119,944.50
Shoe and Tailor Shop				5,724.90
Fire and Police Station				13,207.67
Clubhouse, Alterations and Equipment				328,741.13

Item	Unit	Unit Cost or Price	Quantity	Amount
Diablo Heights (Gold) (Continued)				
Commissary Alterations				$ 713.03
Dispensary				19,193.58
School				70,599.48
Mess Hall Alterations				34,569.16
Gymnasium				80,601.16
Playgrounds and Equipment				70,772.02
Preparation of Site and Landscaping				152,941.73
Roads, Streets, Walks, and Parking Areas				146,108.50
Water Lines				22,620.47
Sewer Lines				53,704.33
Power and Light System				52,848.78
Street Lighting System				9,491.02
Fire-Alarm System				875.94
Paving Under Buildings				39,139.59
Supervision and Inspection				6,546.64
Overhead				92,024.00
Total, Diablo Heights				$2,474,183.76
Gamboa (Gold)				
Type 102 Cottage (1)	ea.		1	$ 11,099.10
Type 201 Apartment Building (12)	ea.	$41,397.58	12	496,770.94
Type 215 Apartment Building (4)	ea.	20,242.06	27	546,535.58
Type 217 Apartment Building (4)	ea.	21,543.69	5	122,718.37
40-Room Bachelor Building			1	49,393.84
Gymnasium Alterations (Design)				2,321.45
Preparation of Site and Landscaping				100,631.39
Roads, Streets, and Parking Areas				135,506.65
Water Lines				36,890.27
Sewer Lines				41,797.93
Power and Lighting Services				34,935.52
Street Lighting System				12,771.13
Fire-Alarm System				443.53
Paving Under Buildings				2,089.84
Supervision and Inspection				1,380.21
Overhead				63,434.00
Total, Gamboa (Gold)				$1,658,719.75
Gamboa (Gold) Contract				
Type 217 Apartment Building(4)	ea.	$20,009.00	2	$ 40,018.00
Material and Services Furnished the Contractor				6,775.68
Total, Gamboa (Gold) Contract				$ 46,793.68
Total, Gamboa (Gold)				$1,705,513.43

Item	Unit	Unit Cost or Price	Quantity	Amount
Gamboa (Silver)				
288/432-Man Bachelor Barracks	ea.	$38,992.22	2	$ 77,986.45
Bunk Boiler				3,550.31
Mess Hall				78,125.05
Preparation of Site				8,629.50
Roads, Streets, and Parking Areas				2,116.49
Water Lines				2,329.25
Sewer Lines				1,535.82
Power and Lighting System				3,100.77
Telephone System				313.45
Street Lighting System				660.02
Fire-Alarm System				125.44
Supervision and Inspection				37.39
Overhead				6,895.00
Total, Gamboa (Silver)				$ 185,404.94
Miscellaneous Construction				
Gorgas Section E Annex				$ 135,528.12
Gorgas Nurses' Quarters, Section E				41,298.56
Gorgas Services Section E				20,111.69
La Boca 100-Man Barracks				50,942.41
La Boca Mess Hall				63,530.50
288/432-Man Barracks				34,231.41
Atlantic Storehouse				14,907.28
Pacific Storehouse				31,889.33
Supervision and Inspection				350.53
Overhead				15,173.00
Total, Miscellaneous				$ 407,962.83
Miscellaneous Townsite Equipment				$ 30,133.05
Total, Townsites				$12,263,313.79
DISTRIBUTIVE COSTS				
Overhead				
Cost				$2,475,342.02
Distributed				(2,475,342.02)
Balance				0
Construction Buildings				
Cost				$ 474,234.96
Distributed				(253,111.35)
Balance				$ 221,123.61 (1)

Item	Unit	Unit Cost or Price	Quantity	Amount
Division Furniture and Equipment				
Cost				$ 216,867.93
Distributed				(124,492.62)
Balance				$ 92,375.31 (1)
Dredging Equipment				
Cost				$7,234,507.36
Distributed				(1,310,008.91)
Balance				$5,924,498.45 (2)
Dredging Equipment, Custodianship				$ 11,064.23
Dredging Depreciation, Deferred				119,656.43
Total				$ 130,720.66 (2)
Transportation Equipment				
Cost				$ 326,324.01
Distributed				(260,002.83)
Balance				$ 66,321.18 (2)
Total, Undistributed				$6,435,039.21 (3)
TOTAL COST MODIFIED THIRD LOCKS PROJECT (June 30, 1944)				$72,953,963.50

(1) Applicable to remaining work to be done upon resumption of work.
(2) To be either distributed to remaining work to be done or transferred to Panama Canal Capital Cost Accounts.
(3) Not applicable to work performed as of this date.

* Contract prices for amounts which were not expended because of termination, therefore, they are not included in the Total or Subtotal Costs.
** Included under other items of cost and are shown here to present the total cost of the feature.

APPENDIX D

PREVAILING HOURLY WAGE RATES AS OF APRIL 1, 1943

	Average Canal Zone		Wunderlich & Okes PC1p-571	Panama Constr. Inc. PC1p-602
GOLD				
Blacksmith	$1.595		$1.75	$1.75
Carpenter	1.523		1.50	1.50
Checker	0.844		1.10	1.10
Electrician	1.559		1.50	1.75
Helper	1.056		1.10	1.10
Laborer	0.602	0.26-0.30*	1.10**	0.25-0.34*
Lineman and Cablesplicer	1.491		1.50	1.75
Mason	1.584		0.45*	0.45*
Mechanic and Machinist	1.540		1.50	1.50
Oiler and Greaser	1.118		1.10	1.25
Operator, Concrete Mixer	1.306		0.45*	1.50
Operator, Crusher	1.664		--	1.50
Operator, Drill and Jackhammer	1.509		1.25	1.25
Operator, Shovel and Crane	1.754		2.00	2.00
Operator, Tractor and Auto Patrol	1.529		1.50	1.50
Painter	1.546		1.00	1.50
Plumber and Pipe Fitter	1.561		--	1.50
Powderman	1.584		1.50	2.00
Pumpman	1.492		1.10	1.25
Sheetmetal Worker	1.547		--	--
Steelman and Riveter	1.518		--	1.50
Truck Driver	1.124		1.10	1.25
Watchman	0.748		0.45*	0.45*
Welder	1.593		1.50	1.50
SILVER				
Artisan	0.398		0.45	0.60
Semiskilled	0.317		0.35	0.50
Unskilled	0.279		0.26	0.35

* Silver
** Misclassified, actually operators

APPENDIX E

OCEAN FREIGHT RATES
ATLANTIC AND GULF/PANAMA CANAL ZONE
COLON AND PANAMA CITY CONFERENCE

Cristobal, Canal Zone, and Colon, Republic of Panama

Class Rates

Class	Cubic Foot	100 Lb.	Description
D	$0.98	$1.96	Dangerous, Hazardous, Objectionable
First	0.52	1.04	Chemicals, Instruments, Nitrogen
Second	0.40	0.80	Tools, Electric Cable, Bulbs
Third	0.35	0.70	Office Machines, Copper, Brass, Bronze
Fourth	0.29	0.58	Machinery, Construction Equipment, Billet

Commodity Rates

Commodity Rates take preference over Class Rates

Commodity	Effective Date	Cubic Foot	100 Lb.
Automobiles, Motor Vehicles, Trailers, Chassis	5/8/42	$ 0.18	$ 0.36
Motor Vehicle Parts	5/8/42	0.25	0.50
Cement (bagged)	5/8/42		0.30
Conduit and Pipe, Metal (not over 8 inch I.D.)	8/12/40		0.52
Dynamite	8/12/40		1.73
Iron and Steel not Parts of Machinery or Plated	8/12/40	0.26	0.52
Lumber, Timber, Ties, not Treated, per Mbm.	8/12/40	11.50	
Lumber, Timber, Ties, Chloride or Salt Treated, per Mbm.	8/12/40	12.65	
Lumber, Timber, Ties, Creosote Treated, per Mbm.	8/12/40	14.95	
Poles and Piling, not Treated			
4-in. to 6-in. Tip, 8-in. to 14-in. Butt, per lin.ft.	8/12/40	0.14#	
6-in. to 10-in. Tip, 8-in. to 14-in. Butt, per lin.ft.	8/12/40	0.21#	
8-in. to 12-in. Tip, 15-in. to 16-in. Butt, per lin.ft.	8/12/40	0.25#	
Shovels and Spades, Hand	8/12/40		1.05
Tires, Tubes, Parts (Take standard measurements)	8/12/40	0.35	0.70

* Plus lighterage charge of $100 on lots up to 175 tons
\# When creosoted add 20 per cent

Notes: These rates do not include Marine Insurance.
Pieces or packages weighing in excess of 6000 pounds and to 110,000 pou will be assessed an additional charge per 100 pounds ranging between $0.15 and $1.47 depending on the weight of piece or package.
Isthmian Transfers are at the rate of $100 per carload or $2.00 per to for less than carload.
Tollage at New Orleans is $0.15 per ton additional.
The above rates were in effect on October 31, 1942. The latest revisi was made on the effective date shown. Effective January 28, 1942 a war surcharge was added to all ocean freight rates. At the present time all rates are established by the War Shipping Administration.

APPENDIX F

FUTURE CONTRACTS, SCHEDULE QUANTITIES

CONTENTS

APPENDIX F

FUTURE CONTRACTS, SCHEDULE QUANTITIES

Item No.	Quantity	Unit	Description
			CEMENT
1	6,000,000	bbl.	Portland Cement
			NEW PACIFIC LOCKS CONSTRUCTION
1	150,000	cu.yd.	Excavation, Class "A", Miraflores
2	1,360,000	cu.yd.	Excavation, Class "B", Miraflores
3	130,000	cu.yd.	Excavation, Class "C", Miraflores
4	2,800,000	cu.yd.	Excavation, Class "A", Pedro Miguel
5	2,530,000	cu.yd.	Excavation, Class "B", Pedro Miguel
6	60,000	cu.yd.	Excavation, Class "C", Pedro Miguel
7	8,100,000	cu.yd.	Excavation, Class "A", Upper Pedro Miguel Approach Channel
8	9,930,000	cu.yd.	Excavation, Class "B", Upper Pedro Miguel Approach Channel
9	3,100	cu.yd.	Excavation, Caissons
10	35,400	cu.yd.	Excavation, Piers
11	1,600	cu.yd.	Excavation, Tunnel
12	36,700	cu.yd.	Excavation, Unclassified, for Diversion Channels
13	500	cu.yd.	Excavation, Exploratory Drifts
14	130,000	cu.yd.	Grading, Unclassified, for Railroad and Highway Construction
15	600,000	cu.yd.	Reclaiming Rock for Concrete Aggregate
16	2,000,000	cu.yd.	Crushing and Stock-Piling Rock for Concrete Aggregate
17	3,860,000	sq.ft.	Foundation Preparation
18	235,000	sq.ft.	Shale Protection
19	11,000	lin.ft.	Drilling 1-1/2-in. Grout Holes, 25 ft. and less in depth
20	9,000	lin.ft.	Drilling 1-1/2-in. Grout Holes, over 25 ft. in depth
21	15,000	lin.ft.	Drilling 2-1/8-in. Core Holes
22	80,800	lin.ft.	Drilling 2-1/2-in. Anchor Bar and Weep Holes
23	100	lin.ft.	Drilling 8-in. Anchor Bar Holes
24	1,500	lin.ft.	Drilling 8-in. Concrete Cores
25	650	each	Pressure Grouting, Connections

Item No.	Quantity	Unit	Description
26	20,000	cu.ft.	Pressure Grouting
27	475,000	cu.yd.	Backfill, Impervious
28	3,200,000	cu.yd.	Backfill, Pervious
29	65,000	cu.yd.	Derrick Stone
30	3,800	cu.yd.	Riprap, Grouted
31	1,900	cu.yd.	Gravel, Drain
32	1,013,000	cu.yd.	Concrete Below Operating Level, Miraflores
33	762,000	cu.yd.	Concrete Below Operating Level, Pedro Miguel
34	547,000	cu.yd.	Concrete Above Operating Level, Miraflores
35	419,000	cu.yd.	Concrete Above Operating Level, Pedro Miguel
36	195,000	cu.yd.	Concrete in Approach Walls, Miraflores
37	304,000	cu.yd.	Concrete in Approach Walls, Pedro Miguel
38	125,000	cu.yd.	Concrete in Floors and Sills, Miraflores
39	112,000	cu.yd.	Concrete in Floors and Sills, Pedro Miguel
40	3,800	cu.yd.	Concrete in Central Control Station, Miraflores
41	2,800	cu.yd.	Concrete in Central Control Station, Pedro Miguel
42	820	cu.yd.	Concrete in Locomotive Service Buildings, Miraflores
43	820	cu.yd.	Concrete in Locomotive Service Buildings, Pedro Miguel
44	21,700	cu.yd.	Concrete, Caissons, Piers and Tunnel
45	1,650	cu.yd.	Concrete for Return Track, Miraflores
46	200	cu.yd.	Concrete for Return Track, Pedro Miguel
47	6,300	cu.yd.	Concrete, Miscellaneous, Miraflores
48	4,400	cu.yd.	Concrete, Miscellaneous, Pedro Miguel
49	4,700	lin.ft.	Concrete Piles
50	20,600	lin.ft.	Concrete Pipe, 4-in.
51	4,100	lin.ft.	Concrete Pipe, 18-in.
52	1,800	lin.ft.	Concrete Pipe, 24-in.
53	5,600	lin.ft.	Concrete Pipe, 30-in.
54	600	lin.ft.	Concrete Pipe, 36-in.
55	27,600	lin.ft.	Precast Concrete Gutter
56	3,875,000	bbl.	Unloading Bulk Cement
57	4,575,000	tons	Unloading Aggregates
58	442	Mbm	Timber
59	16,400	lin.ft.	Fence
60	128,500,000	lb.	Steel, Reinforcing
61	45,540,000	lb.	Structural Steel
62	3,690,000	lb.	Steel, Corrugated Plate

Item No.	Quantity	Unit	Description
63	1,225,000	lb.	Steel, Alloy
64	7,250,000	lb.	Steel Castings
65	756,000	lb.	Steel Forgings
66	6,860,000	lb.	Iron Castings
67	69,900	lb.	Bronze
68	283,000	lb.	Copper Waterstops
69	142,000	lb.	Copper-Wire, Plates, Inserts, and Bars
70	170,000	lb.	Copper-Nickel-Brass
71	178,000	lb.	Babbitt
72	28,300	lb.	Lead
73	12,400	lb.	Rubber, Miscellaneous
74	7,800	lin.ft.	Stair Treads
75	457,000	lb.	Steel Stairs
76	183,000	lb.	Handrail
77	555,000	lb.	Pipe, Cast Iron
78	3,020,000	lb.	Pipe, Steel
79	462,000	lb.	Pipe, Wrought Iron
80	3,800	lb.	Pipe, Brass
81	98,500	lb.	Malleable Iron Pipe Fittings
82	19,600	lb.	Valves, Cast Iron
83	35,400	lb.	Valves, Steel
84	3,700	lb.	Valves, Bronze
85	12	each	Lateral Culvert By-Pass Valves
86	24	each	Miter Gate Crank Recess Valve and Seal
87	6,475,000	lb.	Conduit, Metallic
88	302,000	lb.	Conduit, Nonmetallic
89	1,750,000	lb.	Cable Trays
90	16,700,000	lb.	Emergency Dam, Deck Plate on Dam
91	8,500,000	lb.	Emergency Dam, Structural Steel
92	5,930,000	lb.	Emergency Dam, Cast Steel
93	664,000	lb.	Emergency Dam, Forgings
94	204,000	lb.	Emergency Dam, Copper-Nickel-Brass
95	41,300	lb.	Emergency Dam, Rubber
96	80,800	lb.	Emergency Dam, Roller Bearings
97	168,000	lb.	Emergency Dam, Steel Rails
98	6,760	tons	Emergency Dam, Deck Plate on Sill, Installation
99	25,300	tons	Deck Plate, Installation
100	17,000	tons	Miter Gates, Installation
101	4,830,000	lb.	Lock Valves, Tainter, Installation
102	1,710,000	lb.	Lock Valves, Vertical Rising, Installation
103	3,500,000	lb.	Towing and Return Track System, Miraflores, Installation
104	2,470,000	lb.	Towing and Return Track System, Pedro Miguel, Installation

Item No.	Quantity	Unit	Description
105	1	lump sum	Central Control Station, Miscellaneous, Miraflores
106	1	lump sum	Central Control Station, Miscellaneous, Pedro Miguel
107	1	lump sum	Locomotive Service Buildings, Miscellaneous, Miraflores
108	1	lump sum	Locomotive Service Buildings, Miscellaneous, Pedro Miguel
109	1	lump sum	Service Plumbing, Miraflores
110	1	lump sum	Service Plumbing, Pedro Miguel
111	21,500	sq.ft.	Floor Tile
112	15,900	sq.ft.	Wall Tile
*	1,900	cu.yd.	Bituminous Filler for Towing and Return Tracks Systems

MITER GATES, VALVES, AND BULKHEADS

Schedule A--Miter Gates

1	53,367,000	lb.	Structural Steel
2	9,909,000	lb.	Castings, Steel
3	494,500	lb.	Forgings, Steel
4	213,500	lb.	Copper-Nickel-Brass
5	35,300	lb.	Rubber
6	567,200	lb.	Pipe, Steel
7	248,800	lb.	Fittings, Cast Iron
8	531,100	lb.	Pipe Valves
9	417,400	lb.	Babbitt #6
10	348,900	lb.	Structural Steel, Bridge for Unwatering Gate

Schedule B--Emergency Dam Housing Chamber Entrance Bulkhead and Gate Pintle Inspection Cofferdams

Emergency Dam Housing Chamber Entrance Bulkhead

11	401,800	lb.	Structural Steel
12	780	lb.	Castings, Steel
13	660	lb.	Copper-Nickel-Brass
14	4,000	lb.	Rubber
15	3,800	lb.	Pipe, Steel
16	2,200	lb.	Valves, Pipe

* To be provided for in final draft of specifications.

Item No.	Quantity	Unit	Description
17	0.85	Mbm	Timber
			Gate Pintle Inspection Cofferdams
18	56,400	lb.	Structural Steel
19	680	lb.	Rubber
			Schedule C--Valves and Bulkheads
20	6,892,000	lb.	Structural Steel
21	4,531,000	lb.	Castings, Steel
22	21,900	lb.	Forgings, Steel
23	524,600	lb.	Copper-Nickel-Brass
24	23,100	lb.	Rubber
			PROCESSING CONCRETE AGGREGATES
1	9,000,000	ton	Processing Chagres River Aggregate
2	7,200,000	ton	Loading Chagres River Aggregate
3	2,500,000	ton	Processing Stock-piled Rock at Miraflores
4	740,000	ton	Loading Rock Aggregate
			TOWING LOCOMOTIVES
1	1	each	The design for and the construction, test, and delivery of one (1) "Pilot Model" Electric Towing Locomotive
2	51	each	Construction and delivery of fifty-one (51) "Production Model" Electric Towing Locomotives
			BRIDGES
			New Gatun Locks
1	1,520,000	lb.	Fabricated Structural Steel
2	5,190	sq.ft.	Open Roadway Grating
3	1,470	sq.ft.	Filled Roadway Grating
4	3,630	sq.ft.	Sidewalk Grating
5	252,000	lb.	Machinery
6	33,600	lb.	Racks with Cut Teeth — Alternate I
7	35,800	lb.	Racks with Cast Teeth — Alternate II

Item No.	Quantity	Unit	Description
8	1	lump sum	Electrical Equipment
9	1	lump sum	Signal and Traffic Control System
10	1	lump sum	Counterweight and Adjustments
11	180	lump sum	Concrete
12	8,500	lb.	Reinforcing Steel
			New Miraflores Locks
1	1,870,000	lb.	Fabricated Structural Steel
2	8,720	sq.ft.	Open Roadway Grating
3	1,470	sq.ft.	Filled Roadway Grating
4	4,830	sq.ft.	Sidewalk Grating
5	202,000	lb.	Machinery
6	20,700	lb.	Racks with Cut Teeth — Alternate I
7	21,500	lb.	Racks with Cast Teeth — Alternate II
8	1	lump sum	Electrical Equipment
9	1	lump sum	Signal and Traffic Control System
10	1	lump sum	Adjustments
11	232	cu.yd.	Concrete
12	13,100	lb.	Reinforcing Steel
			NEW GATUN LOCKS CONSTRUCTION
1	386,100	cu.yd.	Excavation
2	3,000,000	sq.ft.	Foundation Preparation
3	1,000	lin.ft.	Drilling 2-1/2-in. Grout Holes, 25 ft. and less in depth
4	1,000	lin.ft.	Drilling 2-1/2-in. Grout Holes, over 25 ft. in depth
5	3,000	lin.ft.	Drilling 2-1/8-in. Core Holes
6	56,900	lin.ft.	Drilling 2-1/2-in. Anchor Bar and Weep Holes
7	40	lin.ft.	Drilling 8-in. Anchor Bar Holes
8	1,000	lin.ft.	Drilling 8-in. Concrete Cores
9	250	each	Pressure Grouting, Connections
10	5,000	cu.ft.	Pressure Grouting
11	171,500	cu.yd.	Backfill, Impervious
12	1,406,000	cu.yd.	Backfill, Pervious
13	15,900	cu.yd.	Gravel Drain
14	1,329,000	cu.yd.	Concrete Below Operating Level
15	727,700	cu.yd.	Concrete Above Operating Level
16	86,800	cu.yd.	Concrete in Upper Approach Walls
17	111,900	cu.yd.	Concrete in Lower Approach Walls
18	177,600	cu.yd.	Concrete in Floors and Sills

Item No.	Quantity	Unit	Description
19	64,700	cu.yd.	Concrete in Extension Slab
20	3,800	cu.yd.	Concrete in Central Control Station
21	820	cu.yd.	Concrete in Locomotive Service Buildings
22	2,650	cu.yd.	Concrete for Return Track
23	6,800	cu.yd.	Concrete, Miscellaneous
24	7,900	lin.ft.	Concrete Piles
25	14,700	lin.ft.	Concrete Pipe, 4-in.
26	1,600	lin.ft.	Concrete Pipe, 18-in.
27	5,000	lin.ft.	Concrete Pipe, 24-in.
28	3,000	lin.ft.	Concrete Pipe, 30-in.
29	380	lin.ft.	Concrete Pipe, 36-in.
30	25,000	lin.ft.	Precast Concrete Gutter
31	2,760,000	bbl.	Unloading Bulk Cement
32	4,400,000	tons	Unloading Aggregates
33	220	Mbm	Timber
34	13,800	lin.ft.	Fence
35	99,810,000	lb.	Steel, Reinforcing
36	32,050,000	lb.	Structural Steel
37	2,563,000	lb.	Steel, Corrugated Plate
38	1,113,000	lb.	Steel, Alloy
39	4,763,000	lb.	Steel Castings
40	389,400	lb.	Steel Forgings
41	4,660,000	lb.	Iron Castings
42	55,500	lb.	Bronze
43	209,000	lb.	Copper Waterstops
44	106,500	lb.	Copper-Wire, Plates, Inserts, and Bars
45	118,000	lb.	Copper-Nickel-Brass
46	127,400	lb.	Babbitt
47	18,900	lb.	Lead
48	9,000	lb.	Rubber, Miscellaneous
49	6,300	lin.ft.	Stair Treads
50	354,600	lb.	Steel Stairs
51	102,600	lb.	Handrail
52	487,400	lb.	Pipe, Cast Iron
53	2,420,000	lb.	Pipe, Steel
54	348,700	lb.	Pipe, Wrought Iron
55	4,600	lb.	Pipe, Brass
56	90,200	lb.	Malleable Iron Pipe Fittings
57	21,300	lb.	Valves, Cast Iron
58	28,300	lb.	Valves, Steel
59	4,200	lb.	Valves, Bronze
60	8	each	Lateral Culvert By-Pass Valves
61	18	each	Miter Gate Crank Recess Valve and Seal
62	4,360,000	lb.	Conduit, Metallic
63	154,300	lb.	Conduit, Nonmetallic

Item No.	Quantity	Unit	Description
64	1,469,000	lb.	Cable Trays
65	8,965,000	lb.	Emergency Dam, Deck Plate on Dam
66	4,590,000	lb.	Emergency Dam, Structural Steel
67	3,158,000	lb.	Emergency Dam, Cast Steel
68	379,300	lb.	Emergency Dam, Forgings
69	116,200	lb.	Emergency Dam, Copper-Nickel-Brass
70	23,400	lb.	Emergency Dam, Rubber
71	46,200	lb.	Emergency Dam, Roller Bearings
72	83,900	lb.	Emergency Dam, Steel Rails
73	17,700	tons	Deck Plate, Installation
74	3,500	tons	Emergency Dam, Deck Plate on Sill, Installation
75	12,800	tons	Miter Gates, Installation
76	3,220,000	lb.	Lock Valves, Tainter, Installation
77	1,098,000	lb.	Lock Valves, Vertical Rising, Installation
78	4,734,000	lb.	Installing Rails for Towing Track, Rack, Collectors, and Insulators
79	1	lump sum	Central Control Station, Miscellaneous
80	1	lump sum	Locomotive Service Buildings, Miscellaneous
81	1	lump sum	Service Plumbing
82	14,200	sq.ft.	Floor Tile
83	10,900	sq.ft.	Wall Tile
*	1,800	cu.yd.	Bituminous Filler for Towing and Return Tracks
*	900	cu.yd.	Concrete in Caissons

OPERATING MACHINERY MOTORS AND BRAKES

1	88	each	Motors for Miter Gate Operating Machines
2	40	each	Motors for Miter Gate Latch Operating Machines
3	40	each	Motors for Miter Gate Stairway Operating Machines
4	44	each	Motors for Lock Culvert Valve Operating Machines
5	40	each	Motors for Lateral Culvert Valve Operating Machines
6	20	each	Motors for Emergency Dam Culvert Valve Operating Machines
7	26	each	Motors for Chain Fender Machines

* To be provided for in final draft of specifications.

Item No.	Quantity	Unit	Description
8	86	each	Brakes for Miter Gate Operating Machines
9	40	each	Brakes for Culvert Valve Operating Machines
10	38	each	Brakes for Lateral Valve Operating Machines
11	20	each	Brakes for Emergency Dam Culvert Valve Operating Machines
12	26	each	Brakes for Chain Fender Machines
			OPERATING MACHINERY
1A	42	each	Miter Gate Operating Machines
1B	1	lot	Spare Parts for Miter Gate Operating Machinery
2A	36	each	Miter Gate Latch Operating Machines
2B	1	lot	Spare Parts for Miter Gate Latch Operating Machinery
3A	36	each	Miter Gate Stairway Operating Machines
3B	1	lot	Spare Parts for Miter Gate Stairway Operating Machinery
4A	40	each	Lock Culvert Valve Operating Machines
4B	1	lot	Spare Parts for Lock Culvert Valve Operating Machinery
5A	36	each	Lateral Culvert Valve Operating Machines
5B	1	lot	Spare Parts for Lateral Culvert Valve Operating Machinery
6A	18	each	Emergency Dam Culvert Valve Machines
6B	1	lot	Spare Parts for Emergency Dam Culvert Valve Machinery
7A	30	each	Emergency Dam Culvert Bulkhead Machines
7B	1	lot	Spare Parts for Emergency Dam Culvert Bulkhead Machinery
8A	24	each	Chain Fender Machines
8B	543,500	lb.	Fender Chain
8C	96	each	Hoists, Chain, Hand-Operated
8D	1	lot	Spare Parts for Chain Fender Machinery
9A	222	each	Power-Operated Watertight Doors
9B	1	lot	Spare Parts for Power-Operated Watertight Doors
10A	36	each	Service Gate and Operating Machinery Lubrication Systems
10B	6	each	Unwatering Gate and Operating Machinery Lubrication Systems
10C	40	each	Culvert Valve Operating Machinery Lubrication Systems
10D	1	lot	Spare Parts for Lubrication Systems

Item No.	Quantity	Unit	Description
			CONTROL AND DISTRIBUTION SWITCHGEAR
1	1	lump sum	Switchboard in Area 1W, Gatun
2	1	lump sum	Switchboard in Area 1E, Gatun
3	1	lump sum	Switchboard in Local Control Room 2W, Gatun
4	1	lump sum	Switchboard in Local Control Room 2E, Gatun
5	1	lump sum	Switchboard in Local Control Room 3W, Gatun
6	1	lump sum	Switchboard in Local Control Room 3E, Gatun
7	1	lump sum	Switchboard in Local Control Room 4W, Gatun
8	1	lump sum	Switchboard in Local Control Room 4E, Gatun
9	1	lump sum	Switchboard in Local Control Room 5W, Gatun
10	1	lump sum	Switchboard in Local Control Room 5E, Gatun
11	1	lump sum	Switchboard in Local Control Room 6W, Gatun
12	1	lump sum	Switchboard in Local Control Room 6E, Gatun
13	1	lump sum	Switchboard in Local Control Room 7W, Gatun
14	1	lump sum	Switchboard in Local Control Room 7E, Gatun
15	1	lump sum	Switchboard in Local Control Room 8W, Gatun
16	1	lump sum	Switchboard in Local Control Room 8E, Gatun
17	1	lump sum	Switchboard in Local Control Room 9W, Gatun
18	1	lump sum	Switchboard in Local Control Room 9E, Gatun
19	1	lump sum	Switchboard in Local Control Room 10W, Gatun
20	1	lump sum	Switchboard in Local Control Room 10E, Gatun
21	1	lump sum	Switchboard in Area 11W, Gatun
22	1	lump sum	Switchboard in Area 11E, Gatun
23	1	lump sum	Switchboard in Area 12W, Gatun
24	1	lump sum	Switchboard in Area 12E, Gatun
25	1	lump sum	Switchgear and Master Control Benchboards in Emergency Control Station, Gatun

Item No.	Quantity	Unit	Description
26	1	lump sum	Switchgear and Master Control Benchboards in Central Control Station, Gatun
27	1	lump sum	Switchboard in Area 1W, Miraflores
28	1	lump sum	Switchboard in Area 1E, Miraflores
29	1	lump sum	Switchboard in Local Control Room 2W, Miraflores
30	1	lump sum	Switchboard in Local Control Room 2E, Miraflores
31	1	lump sum	Switchboard in Local Control Room 3W, Miraflores
32	1	lump sum	Switchboard in Local Control Room 3E, Miraflores
33	1	lump sum	Switchboard in Local Control Room 4W, Miraflores
34	1	lump sum	Switchboard in Local Control Room 4E, Miraflores
35	1	lump sum	Switchboard in Local Control Room 5W, Miraflores
36	1	lump sum	Switchboard in Local Control Room 5E, Miraflores
37	1	lump sum	Switchboard in Local Control Room 6W, Miraflores
38	1	lump sum	Switchboard in Local Control Room 6E, Miraflores
39	1	lump sum	Switchboard in Local Control Room 7W, Miraflores
40	1	lump sum	Switchboard in Local Control Room 7E, Miraflores
41	1	lump sum	Switchboard in Local Control Room 10W, Miraflores
42	1	lump sum	Switchboard in Local Control Room 10E, Miraflores
43	1	lump sum	Switchboard in Area 11W, Miraflores
44	1	lump sum	Switchboard in Area 11E, Miraflores
45	1	lump sum	Switchboard in Area 12W, Miraflores
46	1	lump sum	Switchboard in Area 12E, Miraflores
47	1	lump sum	Switchgear and Master Control Benchboards in Emergency Control Station, Miraflores
48	1	lump sum	Switchgear and Master Control Benchboards in Central Control Station, Miraflores
49	1	lump sum	Switchboard in Area 1W, Pedro Miguel
50	1	lump sum	Switchboard in Area 1E, Pedro Miguel
51	1	lump sum	Switchboard in Local Control Room 2W, Pedro Miguel

Item No.	Quantity	Unit	Description
52	1	lump sum	Switchboard in Local Control Room 2E, Pedro Miguel
53	1	lump sum	Switchboard in Local Control Room 3W, Pedro Miguel
54	1	lump sum	Switchboard in Local Control Room 3E, Pedro Miguel
55	1	lump sum	Switchboard in Local Control Room 4W, Pedro Miguel
56	1	lump sum	Switchboard in Local Control Room 4E, Pedro Miguel
57	1	lump sum	Switchboard in Local Control Room 5W, Pedro Miguel
58	1	lump sum	Switchboard in Local Control Room 5E, Pedro Miguel
59	1	lump sum	Switchboard in Local Control Room 10W, Pedro Miguel
60	1	lump sum	Switchboard in Local Control Room 10E, Pedro Miguel
61	1	lump sum	Switchboard in Area 11W, Pedro Miguel
62	1	lump sum	Switchboard in Area 11E, Pedro Miguel
63	1	lump sum	Switchboard in Area 12W, Pedro Miguel
64	1	lump sum	Switchboard in Area 12E, Pedro Miguel
65	1	lump sum	Switchgear and Master Control Benchboards in Emergency Control Station, Pedro Miguel
66	1	lump sum	Switchgear and Master Control Benchboards in Central Control Station, Pedro Miguel

EMERGENCY DAM OPERATING MACHINERY*

1	1,043,000	lb.	Cylinder Sections, Steel
2	580,000	lb.	Piston Sections, Steel
3	262,100	lb.	Structural Steel
4	388,500	lb.	Steel, Miscellaneous
5	116,000	lb.	Bolts and Studs, Steel
6	25,100	lb.	Brass and Bronze
7	5,000	lb.	Nickel-Copper-Aluminum Alloy
8	10,300	lb.	Nickel-Copper Alloy
9	362,300	lb.	Pipe and Fittings
10	220,500	lb.	Valves, Steel
11	400	lb.	Synthetic Rubber
12	18	each	Centrifugal Oil Pump Units (750 gpm at 150 lb. per sq. in. differential pressure)

* Breakdown does not conform to schedule of bid items.

Item No.	Quantity	Unit	Description
			AUXILIARY ELECTRICAL CONTROL EQUIPMENT
			Schedule A--Watertight Lever-Operated Type Limit Switches
1	16	each	Watertight Lever-Operated Type Limit Switches, Gatun
2	12	each	Watertight Lever-Operated Type Limit Switches, Miraflores
3	8	each	Watertight Lever-Operated Type Limit Switches, Pedro Miguel
4	2	each	Watertight Lever-Operated Type Limit Switches, Spare Gates
			Schedule B--Electronic Type, Variable Coupler, Limit Switches
1	18	each	Electronic type, Variable Coupler, Limit Switches, Gatun
2	14	each	Electronic type, Variable Coupler, Limit Switches, Miraflores
3	10	each	Electronic type, Variable Coupler, Limit Switches, Pedro Miguel
			Schedule C--Watertight Traveling Cam Type Limit Switches
1	114	each	Watertight Traveling Cam Type Limit Switches, Gatun
2	90	each	Watertight Traveling Cam Type Limit Switches, Miraflores
3	70	each	Watertight Traveling Cam Type Limit Switches, Pedro Miguel
			Schedule D--Float Switches
1	175	each	Float switches, Gatun
2	143	each	Float switches, Miraflores
3	110	each	Float switches, Pedro Miguel
			Schedule E--Culvert Air Pocket Indicators
1	16	each	Culvert Air Pocket Indicators, Gatun
2	12	each	Culvert Air Pocket Indicators, Miraflores
3	8	each	Culvert Air Pocket Indicators, Pedro Miguel
			Schedule F--Electric Service Pedestals
1	48	each	Electric Service Pedestals, Gatun

Item No.	Quantity	Unit	Description
2	36	each	Electric Service Pedestals, Miraflores
3	24	each	Electric Service Pedestals, Pedro Miguel

TOWING LOCOMOTIVE TRACK SYSTEM

SCHEDULE I

1A	3,615,400	lb.	Rails, Steel
1B	62,602	lb.	Splice Bars, Steel
1C	6,573	lb.	Track Bolts, Steel
1D	1,625	lb.	Rail Clips, Steel

SCHEDULE II

2A	128,508	lb.	Special Racks, Steel
2B	2,746,463	lb.	Standard Racks, Steel

SCHEDULE III

3A	385,924	lb.	Castings, Carbon Steel
3B	190,406	lb.	Castings, Manganese Steel
3C	1,386	lb.	Castings, Gray Iron
3D	77,008	lb.	Castings, Malleable Iron
3E	596,044	lb.	Rack Chairs, Steel
3F	1,770,202	lb.	Steel, Structural
3G	20,380	lb.	Forgings, Carbon Steel
3H	92	lb.	Springs, Steel
3J	126,582	lb.	Bolts, Steel
3K	8,283	lb.	Bolts, Nickel-Copper Alloy
3M	1,435	lb.	Castings, Bronze
3N	247	lb.	Springs, Phosphor-Bronze

SCHEDULE IV

4A	1,096,491	lb.	Conductor Rails, Copper
4B	54,135	lb.	Bars, Copper
4C	11,123	lb.	Expansion Joints, Copper
4D	16,850	lb.	Bolts, Copper-Silicon Alloy

SCHEDULE V

5A	76,012	lb.	Insulators

Item No.	Quantity	Unit	Description
			VENTILATING SYSTEM
			Schedule I--Centrifugal Type Blowers and Filters*
1	2	each	Centrifugal Type Blower and Filter Unit, 14,400 CFM (Symbol A4)
2	4	each	Centrifugal Type Blower and Filter Unit, 12,800 CFM (Symbol A1)
3	4	each	Centrifugal Type Blower and Filter Unit, 8,800 CFM (Symbol A3)
	2	each	Centrifugal Type Blower and Filter Unit, 8,800 CFM (Symbol A5)
4	6	each	Centrifugal Type Blower and Filter Unit, 8,000 CFM (Symbol A2)
	6	each	Centrifugal Type Blower and Filter Unit, 8,000 CFM (Symbol B3)
5	2	each	Centrifugal Type Blower and Filter Unit, 7,200 CFM (Symbol B2)
6	2	each	Centrifugal Type Blower and Filter Unit, 5,800 CFM (Symbol EDB1)
7	4	each	Centrifugal Type Blower and Filter Unit, 5,600 CFM (Symbol B1)
	6	each	Centrifugal Type Blower and Filter Unit, 5,600 CFM (Symbol C1)
8	4	each	Centrifugal Type Blower and Filter Unit, 5,300 CFM (Symbol EDB2)
9	6	each	Centrifugal Type Blower Unit Complete, 10,500 CFM (Symbol EGB)
10	2	each	Centrifugal Type Blower Unit Complete, 6,000 CFM (Symbol STB3)
11	1	each	Centrifugal Type Blower Unit Complete, 4,400 CFM (Symbol SRB)
12	1	each	Centrifugal Type Blower Unit Complete, 4,000 CFM (Symbol STB1)
	1	each	Centrifugal Type Blower Unit Complete, 4,000 CFM (Symbol STB2)
13	12	each	Centrifugal Type Blower Unit Complete, 2,500 CFM (Symbol ECB)
14	18	each	Centrifugal Type Blower Unit Complete, 2,400 CFM (Symbol PCB)
15	3	each	Centrifugal Type Blower Unit Complete, 1,120 CFM (Symbol OB)
16	20	each	Engine Room Filter Bank Complete with Frame (Symbol F)

* Breakdown does not conform to schedule of bid items.

Item No.	Quantity	Unit	Description
			Schedule II--Axial Flow Fans*
17	24	each	Axial Flow Fan, 35,000 CFM
18	42	each	Axial Flow Fan, 150 CFM
			Schedule III--Air Conditioning Equipment
19	36	each	Local Area Control Room and Ventilation Room Air Conditioning System, complete, but not including Ceiling Diffusers and Air Inlet Register.
20	6	each	Emergency Dam Control Room and Ventilation Room Air Conditioning System, complete, but not including Ceiling Diffusers and Air Inlet Register.
21	3	each	Emergency Power Plant Control Room and Auxiliary Control Room Air Dehumidifying Equipment, but not including Air Register or Ceiling Air Diffusers.
22	3	each	Auxiliary Control Room Air Cooling and Circulating Equipment, complete, but not including Air Inlet Registers.
23	3	each	Emergency Power Plant Control Room Air Cooling and Circulating Equipment, complete, but not including Ceiling Air Diffusers.
24	3	each	Communications Room Air Conditioning Equipment, complete
			Schedule IV--Air Flow Control Equipment
25	10	each	Air Register, 6 ft. 0 in. by 2 ft. 0 in., complete with Louvered Dampers
26	84	each	Air Register, 1 ft. 4 in. by 0 ft. 6 in., complete with Louvered Damper
27	6	each	Air Grille, 1 ft. 2 in. by 1 ft. 2 in.
28	90	each	Ceiling Air Diffuser, 8-in.
29	15	each	Ceiling Air Diffuser, 10-in.
30	12	each	Ceiling Air Diffuser, 12-in.
31	382	each	Ceiling Air Diffuser, 14-in.
32	28	each	Ceiling Air Diffuser, 16-in.
33	6	each	Ceiling Air Diffuser, 20-in.
34	6	each	Ceiling Air Diffuser, 22-in.

* Breakdown does not conform to schedule of bid items.

Item No.	Quantity	Unit	Description
35	12	each	Special Gate Valve, 10-in.
36	326	each	Special Gate Valve, 14-in.

PUMPS AND CONNECTING PIPING

Schedule A--Deep Well Turbine Type Pumps

Pumps

A1	1	each	10,000-gpm. capacity, 75-ft. TDH (Mk. No. P5775-2-50-2)
A2	2	each	2,400-gpm. capacity, 90-ft. TDH (Mk. No. G5775-2-9-20)
A3	2	each	2,400-gpm. capacity, 90-ft. TDH (Mk. No. M5775-2-9-20)
A4	2	each	2,400-gpm. capacity, 90-ft. TDH (Mk. No. P5775-2-9-20)
A5	1	each	1,200-gpm. capacity, 220-ft. TDH (Mk. No. G5795-2-30-2)
A6	1	each	1,200-gpm. capacity, 220-ft. TDH (Mk. No. M5795-2-35-2)
A7	1	each	950-gpm. capacity, 180-ft. TDH (Mk. No. P5795-2-33-2)

Miscellaneous Material

A8	2,500	lb.	Castings, Steel
A9	3,900	lb.	Forgings, Steel
A10	2,100	lb.	Pipe
A11	29,000	lb.	Structural Steel
A12	26,900	lb.	Valves

Schedule B--Lock Dewatering Pumps

Pumps

B1	2	each	38,000-gpm. capacity, 34.5-ft. TDH (Mk. No. G5775-2-30-2)
B2	2	each	38,000-gpm. capacity, 34.5-ft. TDH (Mk. No. M5775-2-30-2)
B3	2	each	38,000-gpm. capacity, 34.5-ft. TDH (Mk. No. P5775-2-30-2)

Item No.	Quantity	Item	Description
			Spare Parts
B4	1	lump sum	Spare Parts
			Miscellaneous Material
B5	15,600	lb.	Castings, Iron
B6	6,700	lb.	Forgings, Steel
B7	6,600	lb.	Pipe
B8	76,400	lb.	Structural Steel
B9	131,400	lb.	Valves, Steel
B10	40,800	lb.	Valves, Cast Iron
			Schedule C--Sprinkler System Pumps
			Pumps
C1	2	each	9,650-gpm. capacity, 205-ft. TDH
C2	6	each	16,800-gpm. capacity, 161-ft. TDH
C3	1	each	19,500-gpm. capacity, 185-ft. TDH
C4	10	each	26,000-gpm. capacity, 217-ft. TDH
			Miscellaneous Material
C5	13,000	lb.	Castings, Steel
C6	28,800	lb.	Forgings, Steel
C7	56,600	lb.	Pipe
C8	11,800	lb.	Structural Steel
C9	53,000	lb.	Valves, Steel
C10	4,000	lb.	Valves, Cast Iron
			Schedule D--Sump Pumps and Sewage Pumps
			Sump Pumps
D1	18	each	20-gpm. capacity, 75-ft. TDH
D2	10	each	20-gpm. capacity, 120-ft. TDH
D3	28	each	50-gpm. capacity, 25-ft. TDH
D4	6	each	50-gpm. capacity, 75-ft. TDH
D5	24	each	100-gpm. capacity, 120-ft. TDH
D6	6	each	250-gpm. capacity, 60-ft. TDH
			Sewage Pumps
D7	2	Duplex Unit	Each Pump, 50-gpm. capacity, 15-ft. TDH

Item No.	Quantity	Unit	Description
D8	2	Duplex Unit	Each Pump, 750-gpm. capacity, 55-ft. TDH
			Miscellaneous Material
D9	1,800	lb.	Castings, Steel
D10	3,500	lb.	Forgings, Steel
D11	5,100	lb.	Pipe
D12	33,000	lb.	Structural Steel
D13	2,400	lb.	Valves, Steel
D14	1,700	lb.	Valves, Brass
			Schedule E--Caisson Type Portable Dewatering Pumps
E1	2	each	400-gpm. capacity, 75-ft. TDH (Mk. No. G5775-2-42-1)
E2	2	each	400-gpm. capacity, 75-ft. TDH (Mk. No. M5775-2-42-1)
E3	2	each	400-gpm. capacity, 75-ft. TDH (Mk. No. P5775-2-42-1)
E4	2	each	2,600-gpm. capacity, 75-ft. TDH (Mk. No. G5775-2-40-1)
E5	2	each	2,600-gpm. capacity, 75-ft. TDH (Mk. No. M5775-2-40-1)
E6	2	each	2,600-gpm. capacity, 75-ft. TDH (Mk. No. P5775-2-40-1)
			Miscellaneous Material
E7	6,000	lb.	Castings, Iron
E8	900	lb.	Forgings, Steel
E9	600	lb.	Pipe
E10	10,100	lb.	Valves
E11	820	lin.ft.	Mill Hose
			MOTOR-OPERATED VALVES*
1	18	each	Motor-Operated Valves, 4-in., 150-lb.
2	162	each	Motor-Operated Valves, 4-in., 300-lb.
3	18	each	Motor-Operated Valves, 6-in., 150-lb.
4	6	each	Motor-Operated Valves, 6-in., 400-lb.

* Breakdown does not conform to schedule of bid items.

Item No.	Quantity	Unit	Description
5	1	each	Motor-Operated Valves, 8-in., 150-lb.
6	12	each	Motor-Operated Valves, 8-in., 400-lb.
7	15	each	Motor-Operated Valves, 10-in., 150-lb.
8	12	each	Motor-Operated Valves, 10-in., 400-lb.
9	36	each	Motor-Operated Valves, 12-in., 150-lb.
10	3	each	Motor-Operated Valves, 14-in., 150-lb.
11	2	each	Motor-Operated Valves, 18-in., 150-lb.
12	42	each	Motor-Operated Valves, 20-in., 150-lb.
13	17	each	Motor-Operated Valves, 24-in., 150-lb.
14	17	each	Motor-Operated Valves, 30-in., 150-lb.
15	176	each	Valve Operators Complete with stand for 18-in., 125-lb. Miter Gate Flooding Valves.
			COMPRESSED AIR SYSTEM
1	18	each	Air Compressors, complete with auxiliaries
2	144	each	Air Receivers
3	106,277	lb.	Shop Fabricated Piping
4	4,888	lb.	Pipe and Screwed Fittings under 3-in. I.P.S.
5	18	each	Valves, Solenoid Operated, 1-in., 150-lb.
6	198	each	Valves, Flanged, Relief, 2-in., 300-lb.
7	54	each	Valves, Flanged, Relief, 4-in., 300-lb.
8	216	each	Valves, Flanged, Check, 4-in., 300-lb.
9	72	each	Valves, Flanged, Gate, 4-in., 300-lb.
10	36	each	Valves, Flanged, Pressure-Regulating, 4-in., 300-lb.
11	18	each	Valves, Screwed, Globe, 1-in., 150-lb.
12	18	each	Valves, Screwed, Gate, 1-1/2-in., 150-lb.
13	18	each	Valves, Screwed, Pressure-Regulating, 1-1/2-in., 150-lb.
14	144	each	Trap, Water
15	216	each	Gages
16	36	each	Thermometers
17	918	lb.	Structural Steel
18	96	lb.	Machine Bolts
			DIRECT CURRENT SUBSTATIONS*
1	10	set	Conversion Equipment, consisting of one 1000-kw., Direct-Current Rectifier together with its associated Rectifier

* Breakdown does not conform to schedule of bid items.

Item No.	Quantity	Unit	Description
			Transformer and the necessary Auxiliary, Protective and Control Equipment for converting 11,500-volt, 3-phase, 60-cycle alternating current to 275-volt direct current.
2	1	set	Balancer Set, 4000 amperes in neutral, 137.5/275 volts, with Switchgear for use with one Converter Unit at Gatun for supplying 3-wire direct-current service to Emergency Dry Dock.

MECHANICAL EQUIPMENT INSTALLATION--PACIFIC

1	24	each	Installation of Miter Gate Operating Machines
2A	20	each	Installation of Gate Latch Operating Machines
2B	2	each gate	Latch Hooks for Spare Miter Gates
3	20	each	Miter Gate Stairway Operating Machines
4	24	each	Lock Culvert Valve Operating Machines
5	20	each	Lateral Culvert Valve Operating Machines
6	12	each	Emergency Dam Culvert Valve Machines
7	20	each	Emergency Dam Culvert Bulkhead Machines
8	8	each	Chain Fenders
9	130	each	Power-Operated Watertight Doors
10A	20	each	Service Gate and Operating Machinery Lubrication Systems
10B	4	each	Unwatering Gate and Operating Machinery Lubrication Systems
10C	24	each	Culvert Valve and Operating Machinery Lubrication Systems
11A	20	each	Sprinkler System, Exterior Gate Piping
11B	4	each	Sprinkler System, Exterior Gate Piping, Spare Gates
12	10	each	Sprinkler System Pumps, Miter Gates
13	2	each	Sprinkler System Pumps, Central Control Station
14A	1	system	Sprinkler System Piping, Pedro Miguel
14B	1	system	Sprinkler System Piping, Miraflores
15A	4	each	Unwatering Pumps, Locks
15B	1	each	Unwatering Pump, Gate Dry Dock
16	4	each	Unwatering Systems, Emergency Dam
17A	58	each	Sump Pumps, Miscellaneous
17B	4	each	Sump Pumps, Sewage System

Item No.	Quantity	Unit	Description
18A	1	system	Locks Ventilation Equipment, Pedro Miguel
18B	1	system	Locks Ventilation Equipment, Miraflores
19	4	each	Emergency Dam Operating Machines
20	10	each	Air Compressors
21	10	system	Compressed Air Systems, Piping
			SPRINKLER SYSTEM
1	2,680	lb.	Inserts, Brass
2	291,612	lb.	Pipe and Pipe Fittings, Steel
3	33,456	lb.	Pipe Supports and Miscellaneous Material
			DECK PLATE
1	214,900	lb.	Deck Plate, 1-in.
2	2,933,000	lb.	Deck Plate, 3-in.
3	49,348,000	lb.	Deck Plate, 5-in.
4	36,335,000	lb.	Deck Plate, 10-in.
5	17,180,000	lb.	Deck Plate, 12-in.
			MECHANICAL EQUIPMENT INSTALLATION--GATUN
1	18	each	Miter Gate Operating Machines
2A	16	each	Miter Gate Latch Operating Machines
2B	2	each gate	Latch Hooks for Spare Miter Gates
3	16	each	Miter Gate Stairway Operating Machines
4	16	each	Lock Culvert Valve Operating Machines
5	16	each	Lateral Culvert Valve Operating Machines
6	6	each	Emergency Dam Culvert Valve Machines
7	10	each	Emergency Dam Culvert Bulkhead Machines
8	4	each	Chain Fenders
9	92	each	Power-Operated Watertight Doors
10A	16	each	Service Gate and Operating Machinery Lubrication Systems
10B	2	each	Unwatering Gate and Operating Machinery Lubrication Systems
10C	16	each	Culvert Valve and Operating Machinery Lubrication Systems
11A	16	each	Sprinkler System, Exterior Gate Piping
11B	4	each	Sprinkler System, Exterior Gate Piping, Spare Gate
12A	7	each	Sprinkler System Pumps, Miter Gates

Item No.	Quantity	Unit	Description
12B	1	each	Sprinkler System Pumps, Installation "A"
13	1	each	Sprinkler System Pumps, Central Control Station
14	1	system	Sprinkler System Piping
15	2	each	Unwatering Pumps, Locks
16	2	each	Unwatering Systems, Emergency Dam
17	36	each	Sump Pumps, Miscellaneous
18	1	system	Locks Ventilation Equipment
19	2	each	Emergency Dam Operating Machines
20	8	each	Air Compressors
21	1	system	Compressed Air Systems, Piping

11.5-KV. UNIT SUBSTATIONS*

1	36	assembly	15-kv. Metal-Clad Switchgear
2	1	each	Power Transformer, 450-kva, 11,500-2,400 volts
3	42	each	Power Transformer, 450-kva, 11,500-480 volts
4	36	each	Lighting Transformer, 100-kva, 11,500-120/208 volts

LIGHTING SYSTEM EQUIPMENT

1	162	each	Outdoor Lighting Standards with Fixtures, Complete, Type D
2	150	each	Outdoor Lighting Standards with Fixtures, Complete, Type E
3	2,495	each	Outdoor Lighting Fixtures, Type A
4	780	each	Outdoor Lighting Fixtures, Type B

NOTE: Quantities for other items under this schedule are not available because the design of indoor lighting is not complete.

PORTABLE HOISTING EQUIPMENT

1A	18	each	Portable Bulkhead Hoists
1B	6	each	Electric Trucks
1C	6	each	Hand Trucks

* Breakdown does not conform to schedule of bid items.

Item No.	Quantity	Unit	Description
2	18	each	Bulkhead Slings
3	6	each	Bulkhead Pickup Devices
			CAISSON
1	3,430,000	lb.	Steel for Caisson
2	580	cu.yd.	Ballast Concrete
3	4	each	Pump Unit Assemblies
4	50,000	lb.	Valves (over 3-inch)
5	2	each	Jib Cranes
6	1	lump sum	Overhead Traveling Crane
7	1	lump sum	Ventilating System
8	1	lump sum	Electrical Equipment
			COMMUNICATION SYSTEM
1	1	each	Furnish and Install Complete Communication System, except Cable, Conduit, and Conduit Fittings, Gatun
2	1	each	Furnish and Install Complete Communication System, except Cable, Conduit, and Conduit Fittings, Miraflores
3	1	each	Furnish and Install Complete Communication System, except Cable, Conduit, and Conduit Fittings, Pedro Miguel
4	2,600	lb.	Furnish and Install Conduit and Conduit Fittings, Gatun
5	2,050	lb.	Furnish and Install Conduit and Conduit Fittings, Miraflores
6	1,525	lb.	Furnish and Install Conduit and Conduit Fittings, Pedro Miguel
7	27,500	lb.	Furnish and Install Cable, Gatun
8	20,500	lb.	Furnish and Install Cable, Miraflores
9	15,000	lb.	Furnish and Install Cable, Pedro Miguel