DOUGLAS AIRCRAFT COMPANY
OKLAHOMA CITY, OKLAHOMA

C-47

CONSTRUCTION AND PRODUCTION ANALYSIS

Prepared by:

Industrial Planning Section
Logistics Planning Division
Plans (T-5)
Air Materiel Command
Army Air Forces

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List of Exhibits

Exhibit No.

APPENDIX

ACKNOWLEDGMENT

Grateful acknowledgment is made of the cooperation received from all personnel contacted with particular reference to the individuals listed below for their aid in compiling this case-study.

C. C. Pearson	Plant Manager
L. W. Hagan	General Superintendent
G. L. Wade	Purchasing Agent
J. D. Ramsey	Properties Manager
H. W. Thue	Time Standards, Manager
W. C. Gill	Forms and Procedures Manager
A. E. Johnson	Facilities Control Manager
M. B. McMahan	Capital Equipment Control
R. H. Allen	Plant Engineer
W. L. Sewell	Priorities and Allocations
T. P. Robertson	Personnel Statistics
J. L. McGee	Fabrication and Cost Estimating
M. E. Austin	Jig and Fixture Fabrication

Interviews of great aid were also held with the following AAF personnel.

Major D. E. Eggleston	AAF Plant Representative
W. A. Mathey	Inspector-in-Charge

CONCURRENCE

The preliminary draft of this case study was submitted for criticism and concurrence to the contractor's Santa Monica, California Executive Office; the Los Angeles AAF Procurement Field Office and the Procurement Division, AMC Headquarters. With minor exceptions, the comments and suggestions received, together with certain editorial revisions, have been incorporated in the final edition of this case study.

The contractors coordination refrained from criticism of editorial approach or conclusions and made the following statement:

"Subject analysis is felt to be essentially accurate and comprehensive. Although Douglas Aircraft personnel have seen fit to question the interpretation of certain minor details, the over-all report appears to be a creditable effort on the part of the AAF personnel involved."

INTRODUCTION

This analysis of production acceleration of airframes produced by the Douglas Aircraft Co., Inc., at the Oklahoma City, Oklahoma facility is one of a series of studies made as an integral part of the Industrial Planning program, being conducted by the AMC in connection with its Postwar Planning. These studies are intended to provide the basic data essential to the development of plans and policies for the disposition of aircraft plants and equipment, retention of stand-by facilities and determination of the means required for a rapid expansion of aircraft production in the event of a future emergency.

Among the specific questions to be answered by these analyses are:

1. The rate of plant construction and production progress achieved by selected airplane, engine, propeller, and certain other principal component projects.

2. The methods which have proved successful in accelerating this program.

3. The difficulties encountered and the extent to which they delayed progress.

Each study follows the same general outline as to form of presentation and subjects covered so as to facilitate the formulation of conclusions and recommendations based on the over-all aircraft production record. Each will consist of a section describing the product, contract and plant; a section analyzing construction and production progress; a section dealing with each of the major factors of production separately; and a statistical appendix.

This study covers the record of production acceleration and scope of operations, of the Douglas Aircraft Co., Inc., in the production of the C-47 airplane at the Government-owned facility at Oklahoma City, Oklahoma. This operation may be considered as subsidiary to the company's principal operation conducted at Long Beach, California, where the same product was produced in order to meet the full requirements of the Government for C-47 transport airplanes.

The accomplishment at this facility is noteworthy and proves that a well established organization can expand its operations rapidly even against the many manufacturing difficulties and hazards prevailing during a national emergency.

Data presented in this study were drawn from the official records and files of Headquarters , Air Technical Service Command,

the Midwestern District Office and the company's Oklahoma City office. These sources were supplemented by personal interviews with both AAF and company representatives principally involved in the project. Briefs of the original documents used in the preparation of this report are filed at Headquarters, ATSC, Wright Field, Dayton, Ohio, and are available for further study or reference by authorized persons.

SUMMARY AND CONCLUSIONS

The Douglas Oklahoma City project can be considered a highly satisfactory operation due in a very large measure, to the lengthy and successful experience of the parent Long Beach and Santa Monica plants in the manufacture of this type of airplane, the accomplishment of major design changes at Long Beach prior to the beginning of production at Oklahoma City and the whole hearted cooperation between Oklahoma City and the parent Long Beach and Santa Monica plants.

Construction of the plant, the management, recruiting and training of personnel, procurement of equipment, procurement of materials, subcontracting and all important operational methods and procedures were the result of experience gained in the Santa Monica and Long Beach plants.

The facility was approved by the Plant Site Corporation in December 1941 and by the War Department in January 1942. Facility construction was under supervision of the United States Corps of Engineers and when officially transferred to the AAF (June 1944) total funds expended amounted to $37,812,918.77 comprising 2,432,018 square feet.

First production man-hours began in a warehouse in Oklahoma City in October 1942 and in the plant January 1943. The major portion of machinery and production equipment was installed and advantageously used as rapidly as construction of the plant permitted.

Seventy-five airplanes (knock-downs) were received from the Long Beach plant for assembly at Oklahoma City. With due consideration given the temporary delays in production as the Oklahoma City plant fell back upon its own fabricated parts, the assembly of these knock-downs was of considerable assistance in attaining early production acceleration. The first acceptance of airplanes (knock-downs) occurred March 1943 and the first acceptance of airplanes fabricated and assembled in the Oklahoma City plant, July 1943, 18 months after approval of the project by the War Department. Peak production (322 airplanes) was reached June 1944.

Because of the cooperation received from the parent plants, no major difficulties occurred to cause a serious delay in production. The principal problem being the unavailability of a sufficient quantity of skilled labor during the early production period.

Construction Program

Although construction was not completed until 4 months after the date planned, the company began operations in the partially completed

main building 2 months before it was finished. There were various reasons for delays in construction as noted by a separate section of this report, but it is interesting to note, that only 3 months elapsed from date of go-ahead to the date the first ground was broken for the main building, during which time all work preliminary to construction was accomplished.

The following are the principal factors that retarded the progress of building construction and the installation of the equipment:

1. The condition of the soil was such that more excavation and back-filling were required than anticipated. This condition was aggravated by wet weather.

2. Structural steel was not completely available as anticipated. This necessitated specification revision for substitute design and materials.

3. There were many delays in receipt of other materials which necessitated extensive expediting.

4. Several minor subcontractors did not coordinate their work with the progress of general construction because of difficulty in procuring materials and labor.

5. Although orders for equipment were placed according to plan and substantial deliveries were received early enough to be installed as the main building construction progress, yet there were several urgently needed items that were not received as scheduled. Some were received prior thereto but not in proper sequence for installation, thereby disturbing the planned progress of the facility construction.

Production Program

The production period under study in this report is considered as the time from date of first production labor expended October 1942, to June 1944 when initial peak production was achieved, a period of 20 months. A study of the company's production record during this period falls naturally into 3 parts, as follows:

1. Pre-acceptance Period - October 1942 through February 1943.

2. Initial acceleration period - March 1943 through October 1943.

3. Final acceleration period - November 1943 through June 1944.

An analysis of the favorable and retarding factors affecting the company's acceleration of production in these periods is given as follows:

Pre-acceptance Period - October 1942 through February 1943.

Favorable Factors

1. An entirely new facility with modern production equipment was provided.

2. Construction progressed and machinery was received to the extent that production started 2 months before building was completed.

3. A portion of the pilot line tooling was furnished by the parent plant.

4. 75 sets of airplane parts were furnished by Long Beach.

5. Design and production engineering data supplied by Long Beach was complete and accurate.

6. Management and engineering personnel transferred from company's other facilities were entirely capable for the task.

7. Labor and supervisory personnel were ample, but not skilled nor adequately trained.

8. Labor relations were satisfactory.

9. Very few material shortages existed.

10. Subcontracted items, procured by the parent facility were in ample supply and satisfactory.

Retarding Factors

1. Construction of buildings was not completed on the date planned necessitating operations to begin in a partially completed building.

2. The manufacture of new tooling at Oklahoma City placed a considerable burden upon machine tools and personnel.

3. Manufacturing controls were inadequate. Difficulties were experienced in scheduling of materials, components, and assemblies.

4. Although practically all locally employed direct workers were trained in government sponsored trade schools prior to employment, such training frequently proved inadequate for the job at hand and a considerable amount of in-plant training was necessary.

5. Serious shortage of certain GFE.

Initial Acceleration Period - March 1943 through October 1943.

Favorable Factors

1. Construction had advanced and machinery was received to the extent that production operations progressed more readily.

2. Management and engineering organizations were expanded the better to cope with the expanding production.

3. Finished components were furnished by Long Beach to assist in priming the production lines, which work was delayed in the starting period due to inadequate tooling.

4. Additional toolmakers were acquired or trained to improve the tooling situation.

5. Labor personnel training program progressed, but skills were not developed satisfactorily nor rapidly enough to meet the needs of the program.

6. Labor relations were satisfactory. Supervisory personnel problems were solved during this period except in isolated cases.

Retarding Factors

1. Certain undelivered items of production equipment caused specific operations to be retarded.

2. The unexpected toolmaking burden imposed upon the facility proved too great to be readily relieved, in turn causing the training program to suffer, which resulted in facility failing to prime and maintain its production in the early portion of this period.

3. Methods and supervisory problems in production of the center wing section caused serious delays before they were solved.

4. Raw materials, were in a few cases, in short supply, causing disturbances in smooth production.

5. GFE items were in short supply.

6. Subcontracted items, especially empennage parts, were behind schedule but not to the point of disruption of production.

7. Winterization program caused engineering changes that seriously disturbed final assembly.

Final Acceleration Period - November 1943 through June 1944.

Favorable Factors

1. There were no major constructions in progress to hinder

production.

2. Machine tools and other production equipment were adequate.

3. Labor had acquired the skills as the result of the training program.

4. Labor relations were satisfactory.

5. Supervisory personnel accepted added responsibilities of labor and time control.

6. Rigid and more complete production controls were developed which effected higher overall operating efficiencies.

Retarding Factors

1. Many engineering changes and modifications were made on the airplane but not to the extent of delaying acceptances.

2. Specific GFE items were difficult to maintain in ample supply to assure uninterrupted airplane deliveries.

Conclusions

As a result of research and the formulation of factual data pertinent to the Douglas Oklahoma City project, as summarized above and described in subsequent topical sections of this report, the following general conclusions are submitted.

1. Rapid acceleration achieved by the Douglas Oklahoma City plant was to a very great degree, due to the lengthy and successful experience of the contractor in manufacturing this type of airplane. The C-47 (AAF designation for the DC-3) was one of the few models of peacetime aircraft adaptable to the war effort without extensive engineering development. It is evident that the AAF should at all times, have research and development carried forward to such an extent that the models upon which it will depend, in the event of another emergency, be completely production engineered and ready for mass production.

2. Delay in construction of the plant proved to be one of the retarding factors in airplane production. The unavailability of certain structural steel necessitated the revision of building specifications affected and the use of substitute materials. It is obvious therefore that, should the necessity for rapid construction of new facilities arise, in the case of another emergency, a true picture of the allocation of structural materials be maintained, thus preventing delays in building construction resulting from the shifting of allocations and revisions of building specifications.

3. Numerous items of building equipment including conduit, wiring, cables, etc. were not received as requested, resulting in the frequent substitution of lower grade materials which created a troublesome situation throughout the entire production period. It is evident therefore that should the necessity again arise for rapid building construction, an adequate supply of high quality building equipment be made available as required, thus avoiding confusion and repairs resulting from the use of inferior materials and the consequential delays in production.

4. Although a portion of the pilot line tooling was supplied by Long Beach, the greater part of this tooling was manufactured at Oklahoma City per Long Beach specifications. This placed a heavy burden upon both the machine tool capacity and the inadequately trained personnel in the Oklahoma City plant, resulting in a considerable amount of rejections, salvage and rework. With due credit given the advantages gained in the training of personnel by the manufacture of pilot line tooling, this situation proved to be a retarding factor during the early production period. The AAF should in the case of another emergency, be assured of the availability of pilot line tooling in sufficient quantities to prevent production delays.

5. The first 75 airplanes assembled in the Oklahoma City plant were "knock-downs" received from the parent Long Beach plant. Although delays in production were experienced when the company fell back upon its own ability to manufacture parts. The assembly of these knock-down airplanes proved to be a very beneficial factor in acquainting new personnel with Douglas assembly methods. A new plant with a large portion of insufficiently trained personnel can achieve production acceleration more rapidly, when "knock-downs" are received from a parent plant.

6. Plans for the operation of the Oklahoma City plant were developed by the parent Long Beach and Santa Monica plants. The early success of the Oklahoma City plant can be attributed to the operation of these plans and the close coordination maintained between the Oklahoma City plant and the parent plants. It is evident therefore, that early operational plans, assistance and close cooperation from parent plants is of major importance to early production acceleration.

7. Government scheduling for this facility was unusually accurate and realistic, with the exception of the intermediate production period from July 1943 to October 1943. A very great portion of the success achieved in meeting acceptance schedules was due to accurate government scheduling. Adequate government planning and scheduling based on accurate studies of industrial capacities is therefore essential to the successful operation of the plant.

8. During the first 10 months of the production period,

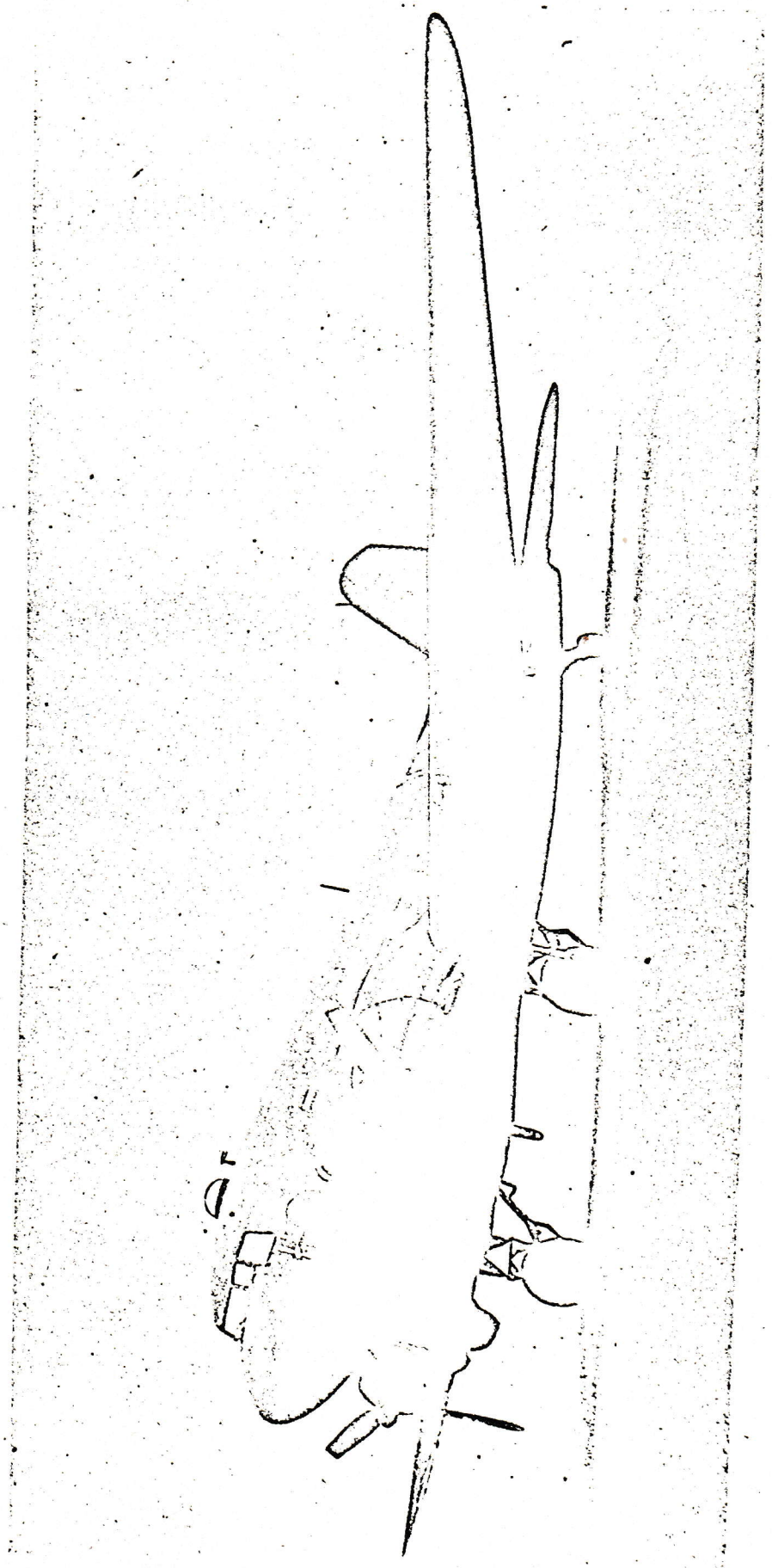
certain production control operations were lacking in functional procedures. This situation was due largely to the quantity of inexperienced personnel on the job and the lack of adequate supervision. Considerable improvement began in September and October 1943 through the shifting of certain supervisory personnel and the placing of workers in positions in which they were most efficient. It is evident therefore that time study and accurate production control methods be adequately maintained during the entire production period.

9. Approximately 75% of all direct workers were trained in government sponsored trade schools prior to employment in the plant. To produce necessary worker efficiency, it was found that a considerable amount of in-plant training was necessary. The acquiring of an efficient labor force was therefore a slow process, consuming considerable amount of supervisory time. The early initiation of government sponsored prerequisite training and vocational schooling directly applicable to work requirements of the individual is a very important factor in the obtaining of early production acceleration.

10. Considerable difficulty was experienced in the receival of certain materials and purchased parts in due time to meet production schedules. This situation was aggravated by the maldistribution of critical materials among aircraft manufacturers who could not accurately predict their requirements. It is evident therefore that one of the factors essential to production acceleration in the case of another emergency, is adequate control of critical materials and the allocation of same in sufficient amounts to meet the demands imposed by government scheduling.

11. The over-all production record of the Douglas Oklahoma City facility is a direct result of the know-how of the parent Long Beach and Santa Monica plants combined with accurate government scheduling and the pre-production training personnel within the immediate vicinity. The importance of these factors can not be overestimated in the aircraft industry.

EXHIBIT NO.1



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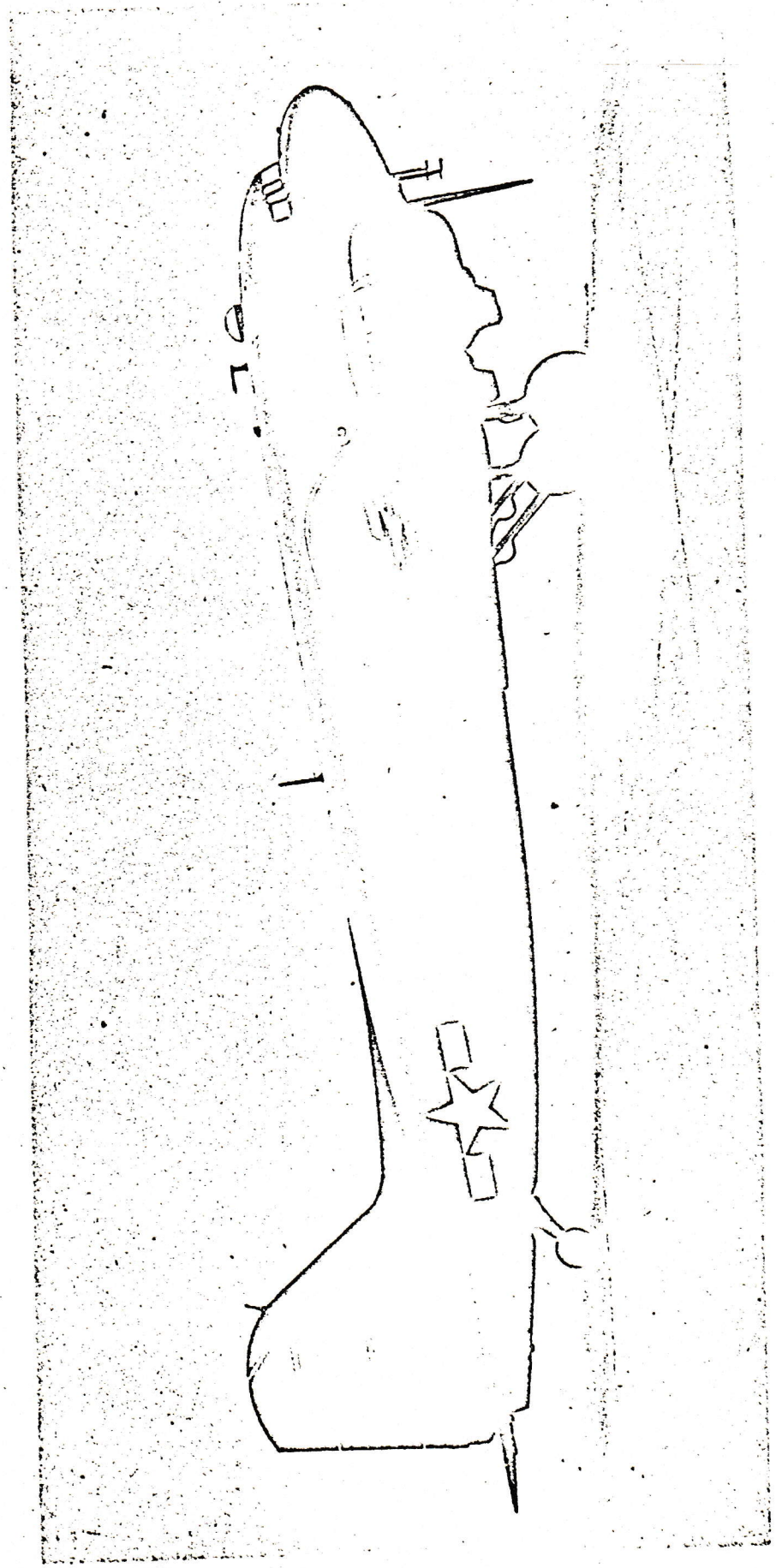

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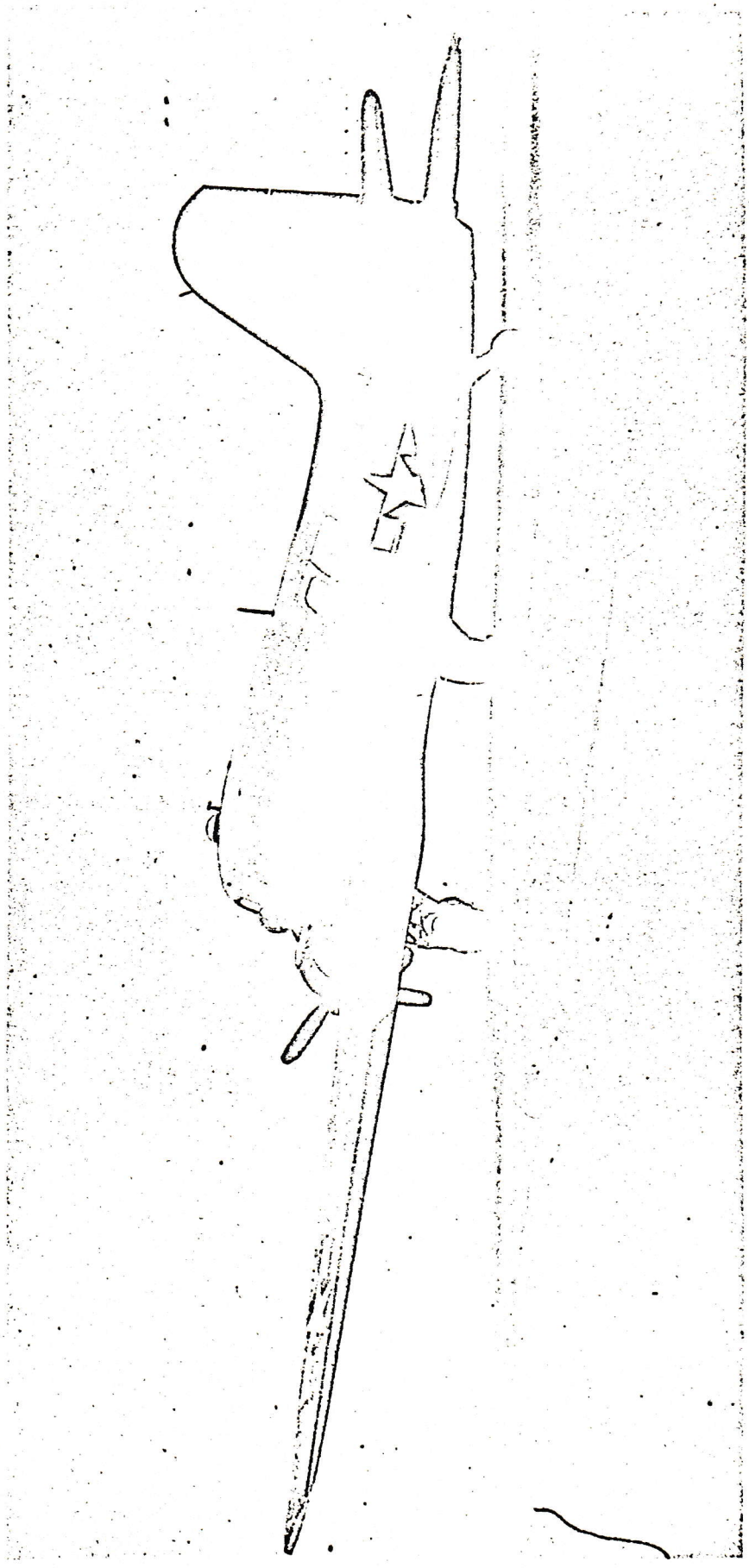


THE PRODUCT

The C-47 is a low-wing, twin engine monoplane designed specifically for the transportation of personnel and/or cargo. This airplane, having unquestionably proven its versatility in time of war, in the transportation of troops and equipment, the dropping of parachutists, conveyance of the wounded, and the towing of gliders, has truly been called "The Workhorse of the Air".

Model C-47 is the Army Air Forces designation given the standard modified military version of the DC-3 airplane introduced by Douglas Aircraft Company, Inc., in 1936. This airplane was the result of approximately 13 years experience on the part of Douglas Aircraft Company, in the design and development of similar types of airplanes prior to its use in World War II, viz., the DC-1 introduced in 1929 and used by commercial airlines, and the DC-2 developed in 1932. The above mentioned DC-3 was in extensive use by TWA as a transcontinental transport at the time of its adoption by the Army Air Forces for World War II. Because of the basic characteristics and proven ability of this airplane, the immediate major changes required by the Army Air Forces were limited to the reinforcement of the floor structure, and enlargement of cargo doors requisite to the transportation of military equipment, and certain cabin revisions necessary for jumping parachutists and for the transportation of wounded in litters.

The performance characteristics of the C-47 airplane described below, remained fairly constant throughout the entire production period.

Maximum speed (10,000 feet altitude).....	229 mph
Cruising speed (5,000 feet altitude).....	208 mph
Landing speed.....	67 mph
Range (normal).....	1500 miles
Ceiling (approximately).....	22000 feet

The following description of the C-47 holds true for both Army and Navy models (Navy model P4D-1).

Wings: All metal cantilever type with straight trailing edge and pronounced sweep-back to leading edge; hydraulically operated trailing edge flaps. Douglas cellular multi-web inner construction; detachable wing tips; fabric covered ailerons.

Fuselage: All metal semimonocoque built up of transverse frames of formed sheet. Longitudinal members of extruded angles. Covering of stressed-skin 24 ST alclad.

Tail Unit: Cantilever monoplane type. Tail and fin of multicellular construction. Rudder and elevators have aluminum alloy frames and fabric covering.

Landing Gear: Retractable type. Wheels raised or lowered in 15 seconds by engine driven hydraulic system. Wheels fold rearward.

Power Plant: Two Pratt and Whitney "Twin Wasp" R1830 SIC3G 14 cylinder radial air-cooled geared and supercharged engines, rated at 1050 HP at 2550 RPM at 7500 feet altitude. (Effective 1 April 1944 on C-47 B airplanes R1830-90C engines used in lieu of R1830-40).

Propellers: Hamilton standard, 3 blade, constant speed, 11 feet, 7 inches diameter.

Fuel Capacity: (Normal - 804 gallons gasoline and 58 gallons of oil)
(Maximum - 1604 gallons gasoline (8 tanks).

Accomodations: Crew 3: (Navy Crew 4) Troop capacity 27: Litter capacity 18. Normal cargo, 6000 lbs: Maximum cargo 10,000 lbs.

Dimensions: Wing span 95 feet
Wing Area 987 feet
Overall Length 64 feet, 5 1/2 inches
Height 16 feet, 11 inches

Weight and Loading:

Weight empty (less fuselage tanks, cradles and partitions	16,861 lbs.
Crew weight	800 lbs.
Normal cargo weight.	6,000 lbs.
Maximum cargo weight	10,000 lbs.
Maximum permissable gross weight	29,000 lbs.

The C-47 has been experimentally fitted with an amphibian twin-float installation with the object of extending the scope of its use. All metal floats of single-step type, were mounted under the engine nacelles. Each float is fitted with 2 retractable wheels, one in the region of the step and one under the nose. Space between the 2 bulkheads in each float is used as an auxiliary fuel tank with a capacity of 300 gallons.

CONTRACT DATA

DOUGLAS AIRCRAFT CO., INC.,
OKLAHOMA CITY, OKLAHOMA
C-47

EXHIBIT NO. 4

CONTRACT NO.	DATE OF FIRST LETTER OF INTENT	DATE CONTRACT APPROVED BY WAR DEPT.	PRODUCT AND QUANTITY	% OF SPARES	(GFE EXCLUDED) AVERAGE PER UNIT INCLUDING FIXED-FEE	REMARKS
WA-535 AC-28405	21 APRIL 42	19 SEPT 42	1800 C-47 200 R4D-1	20%	*$71,630.85	ORIGINAL ESTIMATED COST PER UNIT INCLUDING FIXED-FEE AND SPARES: $89,215. CONTRACT INCLUDED 1800 AIRPLANES FOR THE AAF & 200 FOR THE NAVY. (R4D-1 IS NAVY DESIGNATION FOR C-47).
W535 AC-40652	7 JUNE 43	11 FEB 44	2000 C-47	20%	*$52,770.69	CONTRACT APPROVED 8 MONTHS AFTER DATE OF FIRST LETTER OF INTENT. THIS DID NOT RETARD PRODUCTION BUT CAUSED CONSIDERABLE CONFUSION. MODEL CHANGED FROM C-47A TO C-47B EFFECTIVE ON 3015T AIRPLANE THIS CONTRACT.
W33-038 AC-2032	5 JAN. 44	6 JUN 44	1000 C-47 100 R4D-1	20%	*$49,441.46	ORIGINAL CONTRACT FOR 1000 C-47 AIRPLANES FOR THE AAF AND 100 R4D-1 AIRPLANES FOR THE NAVY WAS REVISED OCT. 1944, CALLING FOR 966 C-47'S AND 134 R4D-1'S.
W33-038 AC-2929	16 MAY 44	19 JUL 44	1800 C-47	20%	*$43,122.50	CANCELLATIONS BETWEEN FEBRUARY AND MAY 1945, REDUCED THIS CONTRACT TO 1184 PLANES (1053 C-47'S AND 131 C-117'S). DURING OCTOBER 1945, THE CONTRACT WAS FURTHER REDUCED TO 264 C-47'S AND 17 C-117'S.

* BUDGET AND FISCAL RECORDS.

EXHIBIT NO.4

CONTRACTS

All airplanes manufactured by the Douglas Aircraft Company facility at Oklahoma City, Oklahoma, were procured on cost-plus-fixed-fee contracts. All contracts were carefully planned and placed in due time and for sufficient quantities to prevent delay in production.

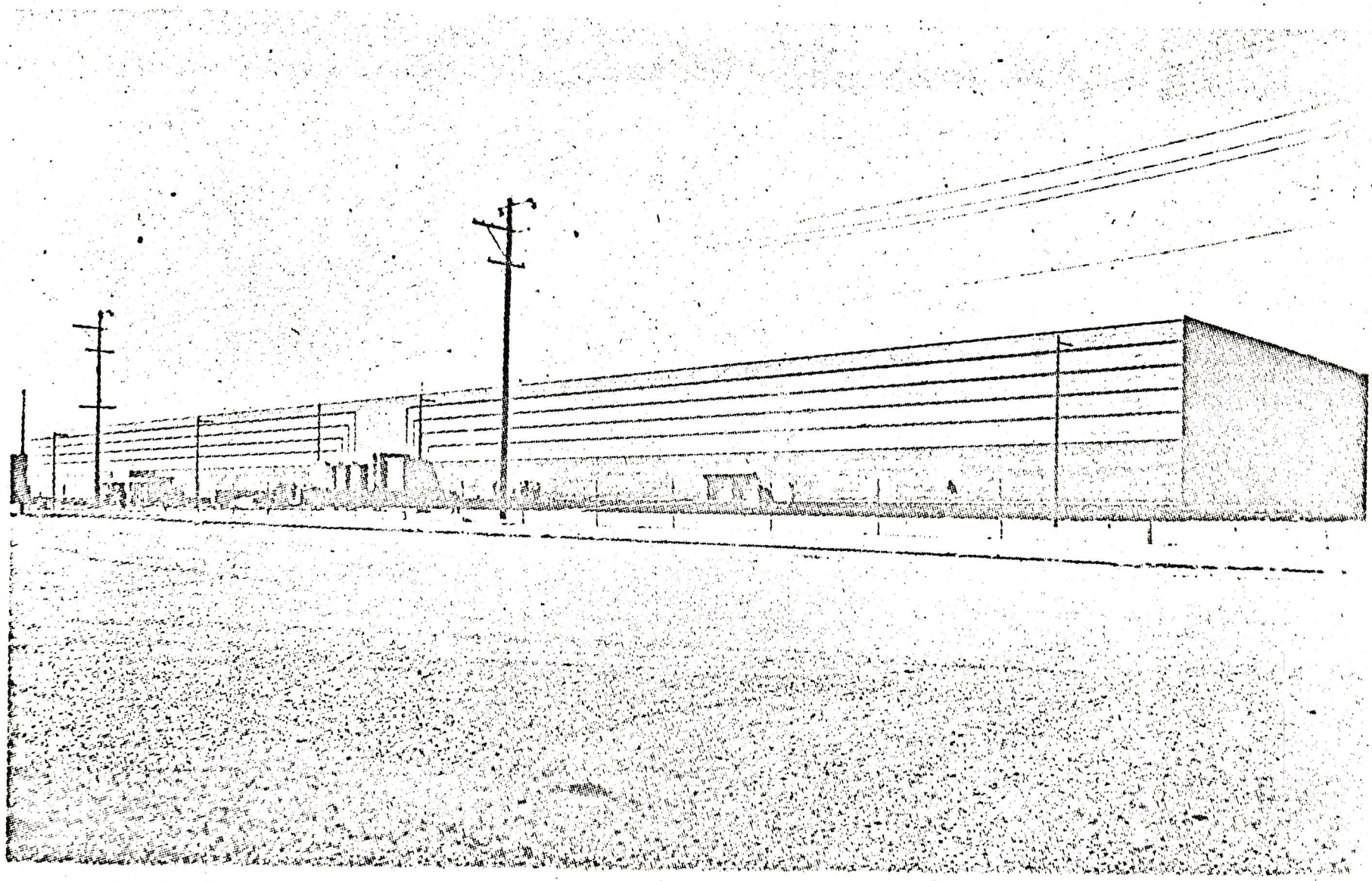
The Army Air Forces plan for the manufacture of transport airplanes at Oklahoma City was made known to the War Department by a letter from Resources Control Section, Materiel Command, Army Air Forces, dated 14 January 1942, addressed to the Secretary of War. At its meeting 1 May 1942, the Joint Aircraft Committee was advised that the Army Air Forces had decided to produce C-47 airplanes in Oklahoma City in lieu of C-54 airplanes as was previously planned. (The transferrence of plans for manufacture of C-54 airplanes from Oklahoma City to Chicago was made April 1942.)

A letter of intent, relative to the manufacture of C-47 airplanes at Oklahoma City, was submitted to Douglas Aircraft Company under date of 21 April 1942. This was followed by a supplemental letter dated 1 May 1942 and by another dated 20 May 1942. All of these related to the terms and conditions under which a formal contract would be awarded. The scope of the proposed contract and the estimate of costs, namely $218,400,000 as indicated by these letters of intent, included the procurement of 2000 C-47 airplanes, 15% spare parts, and also including the new facility to be constructed. In August, the quantity of spare parts to be procured was increased to 20% of the value of the airplane.

The formal contract was approved by the War Department 19 September 1942, in accordance with the letters of intent, and indicated that the average unit cost of the airplanes to the government, including spare parts, would be $89,215.00. This contract was supplemented by additional contracts, each of which increased the quantity of airplanes so that eventually a total of 6900 were procured. A tabulation showing the significant data pertaining to each contract is shown by Exhibit #4.

The exhibit shows a decrease in unit cost to the government as each contract was completed. It is noted that a considerable decrease is shown in the cost per plane by the second contract as compared to the first whereas a normal decrease followed thereafter. The high cost of the first contract is accounted for by the setting up of a new plant, the employment of a large number of insufficiently trained personnel, which included the expense of an extensive training program and related expenses due to scrapped materials and labor of reprocessing. These costs, having been anticipated, were considered allowable expenses to the contract.

The unit cost applying to the second contract is far below

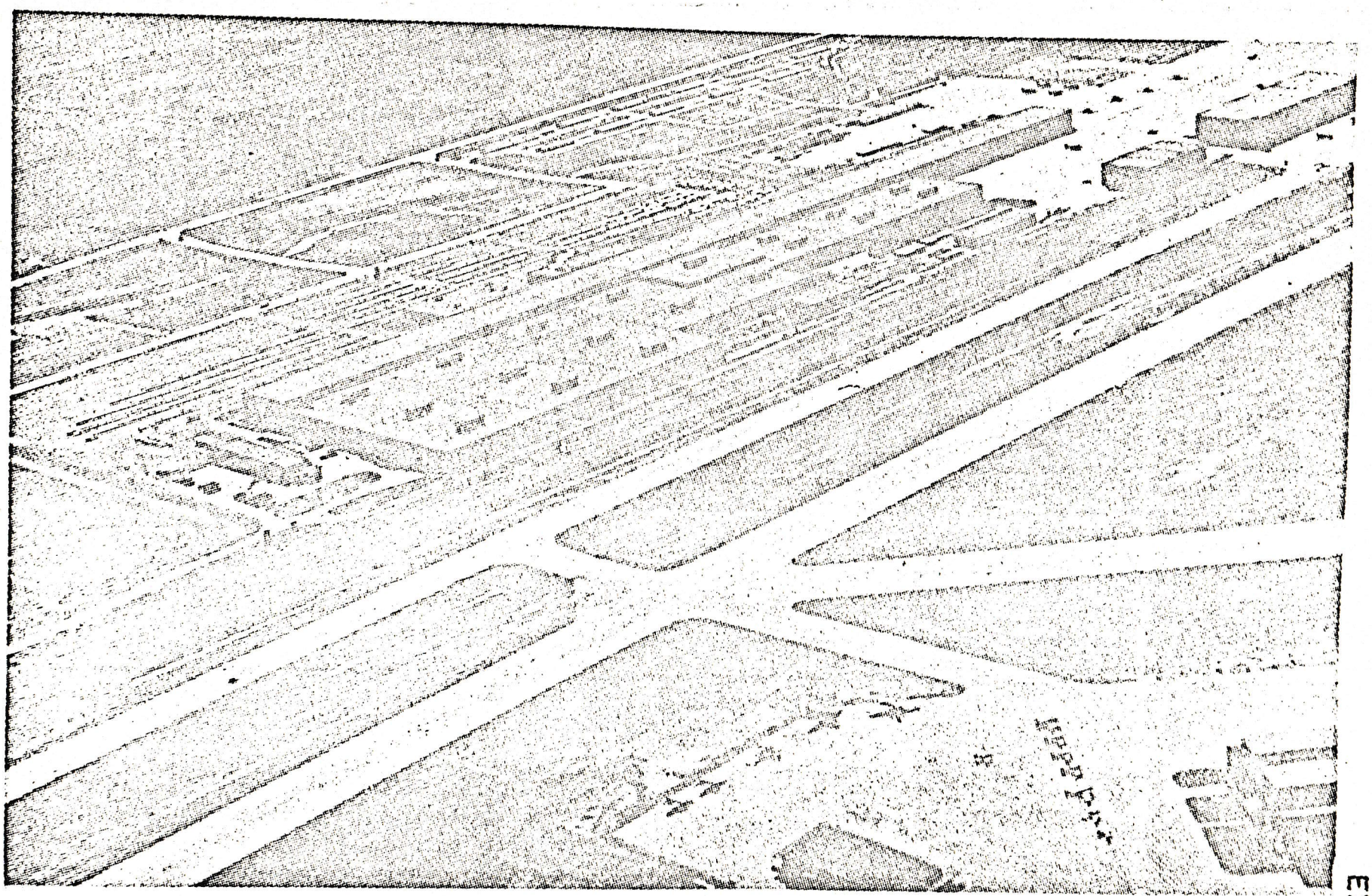


OKLAHOMA AIRCRAFT ASSEMBLY PLANT NO. 5

OFFICE BUILDING

EAST ELEVATION

EXHIBIT NO. 6

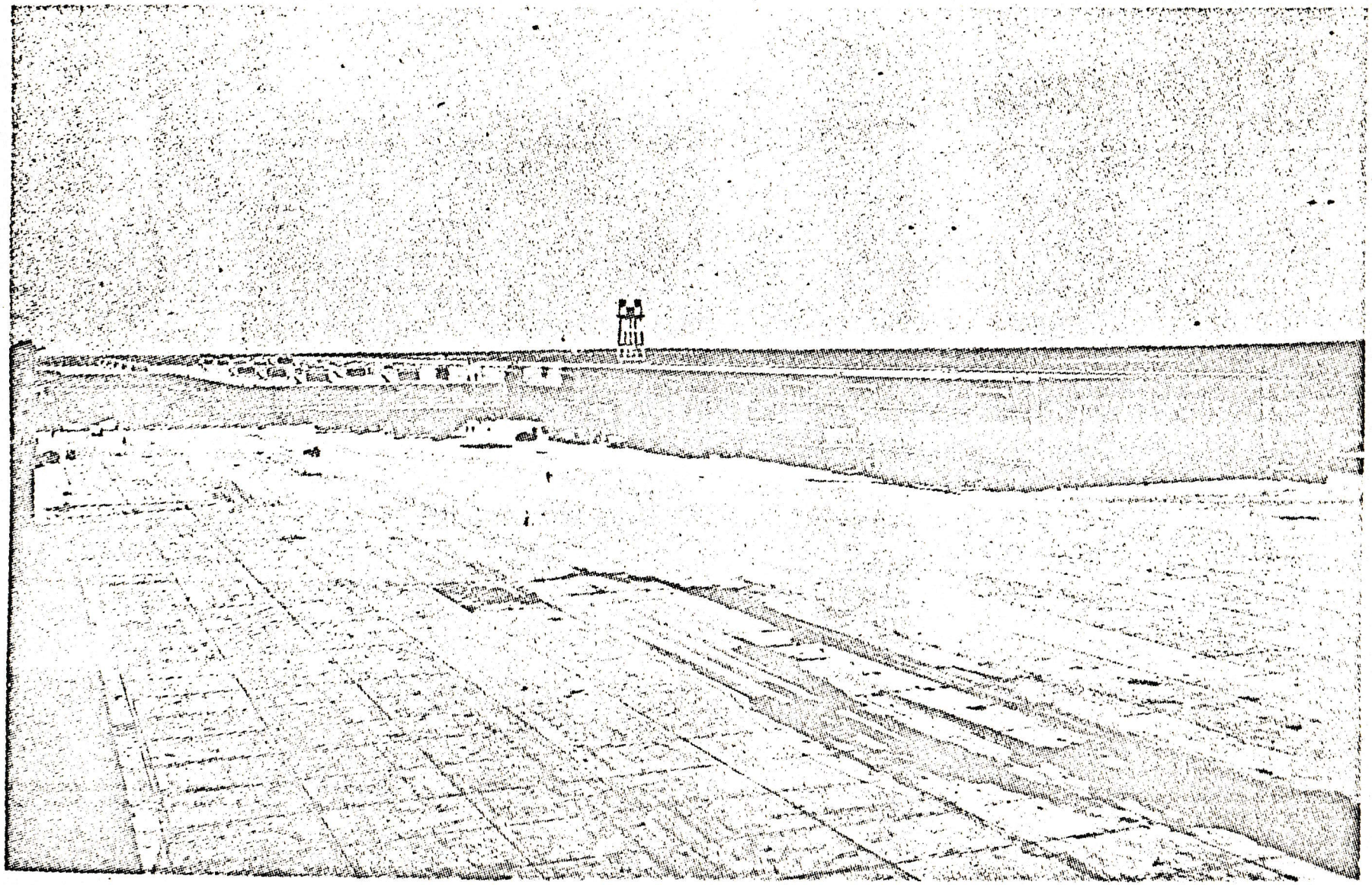


OKLAHOMA AIRCRAFT ASSEMBLY PLANT NO. 5

AERIAL VIEW

LOOKING SOUTHEAST

EXHIBIT NO.5

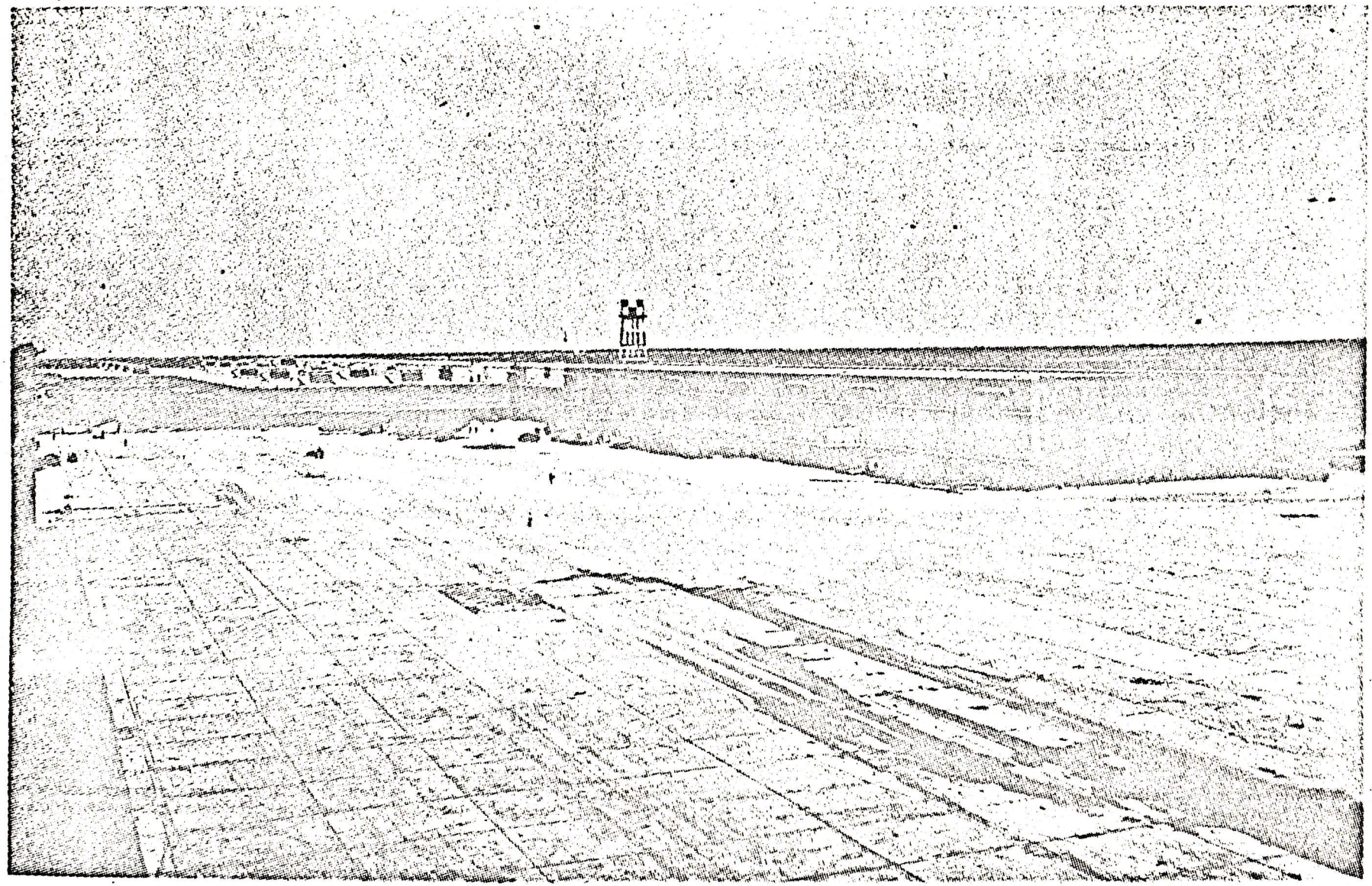


OKLAHOMA AIRCRAFT ASSEMBLY PLANT NO. 5

ASSEMBLY BUILDING

SOUTH & WEST ELEVATION

EXHIBIT NO.7

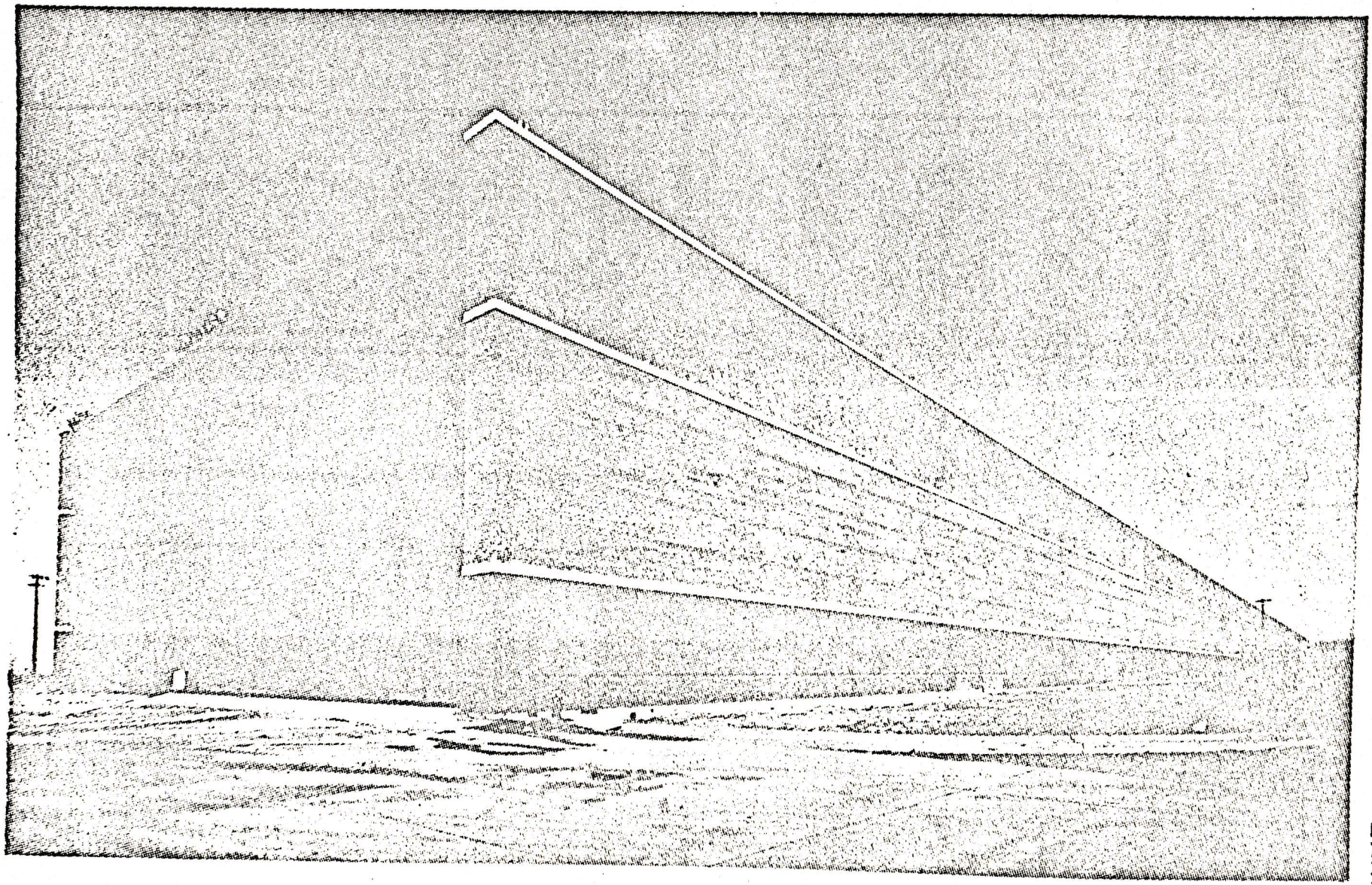


OKLAHOMA AIRCRAFT ASSEMBLY PLANT NO. 5

ASSEMBLY BUILDING

SOUTH & WEST ELEVATION

EXHIBIT NO.7



OKLAHOMA AIRCRAFT ASSEMBLY PLANT NO. 5

ASSEMBLY BUILDING

SOUTH & EAST ELEVATION

EXHIBIT NO. 8

EXHIBIT #9

PLANT
FUNDS EXPENDED

The following is a recapitulation of funds expended as reported to the Facilities Branch, Industrial Facilities Section, Wright Field, 22 June 1944, at which date subject information was transferred to the Facilities Branch from the United States Army Corps of Engineers.

1. Land and Improvements.

a.	Land		1.00
b.	Land Improvements		
	(1)	Grading	371,297.21
	(2)	Drainage & excavation	63,268.24
		Concrete used in drainage and excavation	12,758.67
	(3)	Soil erosion control	45,412.19
	(4)	Storm sewer lines	334,922.69
			$827,660.00

2. Buildings, Building Installation (not mechanical), Lease-Hold Improvements, Off-lease Improvements and Service Costs.

a.	Buildings	10,475,281.67
b.	Building Installations (not mechanical)	7,588,683.70
c.	Lease-Hold improvements (including pavement of parking areas, fencing, laying of railroad tracks and utility expense outside the buildings, but on property)	5,069,067.75
d.	Off-lease improvements (including railroad and utility expense not on property)	4,583.75
e.	Service Costs	1,347,243.12
		$24,484,859.99

3. Machinery and Equipment.

a.	Machine tools and production equipment	
	(1) Machine tools	5,985,829.86
	(2) Production equipment	609,752.02
b.	Building installations (mechanical)	2,406,979.70
c.	Laboratory and testing equipment	194,714.78
d.	Furniture and fixtures	1,056,282.68
e.	Office equipment	917,684.14
f.	Dispensary equipment	8,143.71
g.	Cafeteria equipment	75,548.95
		$11,254,935.84

4. Portable tools, Automotive Equipment and material handling equipment.

a.	Portable tools	672,320.92
b.	Automotive equipment	481,633.81
c.	Material handling equipment	91,508.21
		$ 1,245,462.94
	GRAND TOTAL	$37,812,918.77

THE PLANT

Summary

A study of the construction progress of the Douglas Aircraft Company, Inc., Oklahoma City facility, reveals an overall satisfactory performance of the construction contractor and excellent cooperation on the part of Douglas Aircraft Company, Inc.

The facility was sponsored by the AAF and War Department owned. The location was originally approved by the Plant Site Corporation 31 December 1941 and approved by the War Department January 1942; the "go-ahead" given Douglas Aircraft Company, Inc., January 1942 and the construction contract awarded Austin Company of Cleveland, Ohio in February 1942.

When officially transferred from the United States Army Corps of Engineers to the AAF, the total funds expended were $37,812,918.77. Refer to Exhibit #9 for breakdown of expenditures. The funds expended up to 30 September 1945, however, had increased to $39,911,434.46. The total covered area was 2,432,018 sq. ft. and the total hardsurfaced area not covered, was approximately 2,374,000 sq. ft. See Exhibit #12 for breakdown of square footage area.

Initiation of Project

Selection of the Oklahoma City plant site was based on several anticipated advantages, the most important of which were as follows:

a. Located near geographical center of the nation.
b. Adjoined existing Tinker Field with use of its airport facilities.
c. General topography of surroundings favorable to flying.
d. Moderate climatic conditions.
e. Potential labor available.

Land consisting of 350 acres, approximately 4 miles southeast of Oklahoma City, was donated to the Government by Oklahoma City, for the sum of $1.00.

Simultaneously, with the award of the construction contract to the Austin Company, all construction work was placed under supervision of the United States Army Corps of Engineers. Architectual drawings were made by the Austin Company in collaboration with Douglas Aircraft Company, Inc. and the United States Army Corps of Engineers.

The facility was originally designed for the manufacture of C-54 airplanes and in April 1942, Army Air Forces transferred their plans for the manufacture of C-54 airplanes from Oklahoma City to Chicago, deciding at that time to manufacture C-47 airplanes at Oklahoma City. Due to the similarity of facility requirements for these two airplanes, no major changes were made in the original building design.

Description of Plant

All buildings are of steel frame and brick construction, designed for complete black-out. The manufacturing section of the main building has a ceiling clearance of 35 feet over the final assembly lines and a column spacing of 100 feet. The major portion of the sub-assembly and manufacturing areas, have a ceiling clearance of 25 feet and a column spacing of 30 feet. The total area of all buildings (not including Modification Hangars No. 1 and No. 2 which were taken over by Tinker Field) is 2,432,018 sq. ft. (See Exhibit #12 for breakdown of square footage areas).

The facility has use of the adjoining Tinker Field airport with its ample two-directional runways, one 7,500 feet and the other 5,200 feet.

Construction Progress

Ground was broken 8 March 1942 and difficulty immediately experienced because of wet alluvial soil, necessitating additional excavation and causing approximately 3 weeks delay. Difficulty was experienced in procurement of a sufficient quantity of structural steel, necessitating revision of a considerable portion of the specifications for the administration building and causing several weeks delay.

Sufficient quantity of high grade conduit, cables and wiring, could not be obtained, and a considerable amount of inferior quality material was used. While this latter situation did not noticeably delay construction progress, it remained more or less a constant source of trouble throughout the entire use of the facility.

First steel was erected 4 July 1942 and the first roofing was in place the latter part of September 1942. Beneficial occupancy was accomplished as rapidly as completion of the building permitted. The percentages of building completion and beneficial occupancy were approximately as follows:

1 November 1942....15%
15 December 1942....33 1/3%
15 January 1943.....50%
15 February 1943.... 66 2/3%
24 March 1943..... 95%
1 July 1943..... 98%

It is worthy of note, that the original planned completion date was November 1942. This planned completion date, apparently did not give sufficient allowance for retarding factors, the more important of which have been mentioned above. These delays did not retard airplane acceptances and the plant met initial acceptance schedules as explained under the heading "Production Acceleration".

EXHIBIT #12

AREAS OF BUILDINGS AS OF JUNE 1944

Total square footage of buildings (not including modification hangars No. 1 and No. 2 taken over by Tinker Field) 2,432,018

Total covered area - breakdown per floor:

1st floor	2,199,239
2nd floor	190,458
3rd floor	42,321
Total	2,432,018 sq. ft.

Aprons, Ramps and other hard surfaced area (un-covered) 2,374,000 sq. ft.

The above total sq. footage (covered area) is made up of the following detailed list.

Assembly Bldg. (2 floors and service decks)	1,564,182
Administration Bldg	252,039
Hangar	167,545
Lean-tos and sheds	89,529
Garages	20,302
Mill Bldg	19,200
Paint Storage Bldgs	83,213
Incinerator Bldg	1,040
Sewage Disposal Plant (Laboratory)	700
Boiler House	42,658
Fire Protection Pump House	1,089
Sub-station - Switch Gear House	2,280
Cooling tower - Switch Gear House	395
Water Well - Pump Houses (6)	1,238
Guard Houses (24)	3,929
Water Treatment Bldg	156
Warehouses (17)	170,146
Material Conservation Bldg	7,435
Transportation Bldg	4,942

EXHIBIT NO. 63

PRODUCTION ACCELERATION

Summary

The Douglas, Oklahoma City facility succeeded in accelerating its production rapidly, as compared to other producers of large aircraft, because of the unique position of its being a subsidiary plant of a company which had had long experience in the production of the same model airplane. The C-47 had been in production at the company's Long Beach plant for a period of two years prior to the time Oklahoma City began operations.

At the time the Oklahoma City project began, production at Long Beach was comparable in scope to the proposed ultimate production of the new facility. This was a favorable condition in that it was possible for production methods and tooling to follow the same pattern as Long Beach. A new plant was constructed for the specific purpose, and well selected machine tools and other production equipment acquired, and in addition, a portion of the tooling requirement was provided by the parent company. The Long Beach plant provided a nucleus for the new operating organization in the form of administrative, engineering and supervisory personnel. The parent plant also provided the equivalent of seventy-five airplanes in the form of components and sub-assemblies for the purpose of training employees and assisting in priming the production lines.

It is obvious that a more rapid acceleration of production could have been achieved if it had been possible to carry out all phases of the project strictly according to the original plans. Had such been the case approximately 2 to 3 months could have been saved according to the estimate of this analyst. Details of the changed and retarding conditions are presented in the following paragraphs. Despite the difficulties which had to be overcome, after first acceptance in March, 1943 production of the Oklahoma City plant rose to its initial peak of 322 planes in June, 1944. This was a period of 20 months after first production manhours and 16 months after first knock-down acceptances, giving an acceleration rate of twenty planes per month over the period of acceptances; an excellent record for an airplane of this class.

Facility Project

Construction of the buildings was authorized in January 1942 and was planned for completion in November of the same year. The work was actually completed in March 1943 but the main manufacturing building was available for partial occupancy in November 1942. Actual airplane production began in January 1943 or about two months before the building was substantially completed, and two months after the planned date of production starting. (Causes for delayed construction progress are explained under the heading entitled "The Plant"). The major portion of machine tools and production equipment were installed and advantageously put to use proportionately with building completion.

Government Scheduling

The original schedule for airplane acceptance established for this facility by the AAF, was established 7 August 1942. First acceptances were planned for March 1943 and a total of 721 acceptances planned for the

year 1943 with monthly acceptances reaching 208 units in December 1943. For reasons of changing government requirements, unavailability of production equipment, materials or government furnished equipment, or inadequate trained labor and contractors inability to produce as planned, this schedule was revised several times with lower production goals established for the period from August 1943 to January 1944. The maximum monthly production specified was increased in each of the later schedules however, and in the W9 schedule, dated 1 January 1944, which was the latest effective revision prior to peak production being reached. A maximum of 322 planes was planned for June 1944.

Actual accomplishments did not coincide with the revised schedules throughout the whole period of operations, acceptances being on schedule during the early months, lagging from July thru October 1943, and back on schedule, or leading it, from November 1943 thru June 1944, when peak production was attained. This analysis pertains therefore, only to acceptances compared with the effective or prevailing schedules. Refer to Exhibit #14.

Production Plan

Plans for operation of the Oklahoma City facility were developed by the parent Douglas Long Beach and Santa Monica plants, and were based on a maximum of 208 monthly acceptances to be attained 9 months after the initial acceptance scheduled for March 1943. The details of these operating plans were as follows:

a. Transferring personnel from Long Beach to form a nucleus of management, engineering and supervisory organization.

b. Furnishing complete engineering designs and production engineering data.

c. Selection and initiating procurement of production equipment.

d. Designing, producing, and furnishing complete pilot line tooling including jigs, fixtures, templates, dies, gauges, etc.

e. Procurement of material and processing equivalent to seventy-five airplanes in the form of components and assemblies (knock-downs).

f. Procurement of all subcontracted items from vendors currently serving the parent facility.

Production and production control methods were to be patterned after methods of the Long Beach facility.

Labor requirements were estimated based on the experience acquired by the Long Beach and Santa Monica plants adjusted for the lack of training and skills available in the Oklahoma City area. Labor would be recruited upon the assumption that the majority of workers would require on-the-job training before effective utilization could be expected.

Government furnished equipment would be procured according to established practice.

Operation of the Plan

The following analysis is based upon the schedules prevailing for each month, rather than the original schedule authorized; it is interesting to note that although the facility was planned to produce 208 planes per month, an ultimate production of 322 was actually achieved, and that this was accomplished without expanding the facility by either additional buildings or equipment. For clarification of analysis of the actual execution of the above plan, the following discussion of the production period is divided into three sections, namely:

a. Pre-Acceptance Period (October 1942 through February 1943).
b. Initial Acceleration Period (March 1943 to October 1943 inclusive).
c. Final Acceleration Period (November 1943 to June 1944 inclusive).

The Pre-Acceptance Period - October 1942 through February 1943.

First productive labor was expended in October 1942, two months later than the planned starting month. Beginning in January 1943 airplane components and assemblies were received from Long Beach in quantities sufficient to maintain production on the airplanes scheduled for the period.

The main building was not ready for complete occupancy until the last month of this period, and only part of the production equipment was ready for use. It was necessary to transfer three Ceco Stamp presses from another facility at this time. Government furnished equipment was not all being received as planned. There were a few shortages of critical materials at this time.

An adequate labor force was being recruited and placed in training, not only for the further assembly of the parts furnished but for the production of components required for supplying the production lines for the projected schedule requirement after the parts and components received from Long Beach had been assembled into complete planes.

Approximately 40% of the pilot line tooling was received from Long Beach. The major portion of all pilot line tooling was manufactured at Oklahoma City per Long Beach specifications. With due credit given the advantages gained by utilization of all available machine tools and the early training of personnel, this situation, although lessening the load at Long Beach, placed a very heavy burden upon the Oklahoma city plant. The lack of skilled tool makers resulted in numerous rejections and much rework. Many persons were temporarily transferred from other production occupations to machine tool making. Had the Oklahoma City plant, through assistance from Long Beach, been prepared to cope with this situation, it is essential that production acceleration could have been earlier attained.

The labor problem in the early stages of operation was especially

difficult in that the majority of production workers were entirely unskilled, which necessitated long and careful training and resulted in very low overall worker efficiency.

In the productive period from first acceptance of 2 planes in March, 1943 through June, when 30 C-47's were accepted, operations of the Oklahoma City facility met exactly the 8K schedule set by the AAF. This is indicated in the comparison chart (See Exhibit No. 15) showing "Schedules and Acceptances".

In this period Douglas management, with its facility and equipment nearing completion, set for itself two major objectives, viz., first, the assembly of enough planes from the Long Beach parts to meet schedule, and secondly, initiating the fabrication of parts in the new facility, training their personnel at the same time. The first of these two objectives was achieved, but the other was not, as will be indicated in the discussion of the "initial acceleration" period which follows.

Initial Acceleration Period -(March 1943 to October, 1943).

At the beginning of this period, the new factory was substantially complete so far as the buildings were concerned. Some delay had been encountered in completing the monorail system, due to breakage of a wheel forging die. About eighty-five percent of the production equipment had been received and made ready for use. There were some critical items of production equipment undelivered, especially Cecco Stamp presses and hydro presses, necessitating material being furnished to other facilities for processing.

Although all the parts furnished by Long Beach had not yet been assembled into airplanes, the new plant fell 10 planes behind its schedule in the first month of this period. One reason for this was that the question of engineering changes requested by the AAF had already appeared, with the necessity of re-working 17 planes in July 1943.

Critical situations developed in this period in certain production departments, in the machine shop, for example, but more seriously in the center wing section department. As first reported, the failure to keep up center section production was due to a shortage of experienced help. The shortage grew steadily worse, however, increasing to 50 sections behind schedule in August and 85 behind in September. The plant placed more emphasis on its training program in an effort to speed production, calling on Long Beach at the same time for the loan of skilled help, and also attempting to borrow any available wing sections.

As direct result of these production difficulties, and the training program required for machine operators and other types of direct workers, production at Oklahoma City fell approximately 2 months behind the 8L schedule. On 18 October, 1943, the government revised the schedule for this facility, establishing in W8 lower goals for the months immediately ahead, this reduction carrying into the first quarter of 1944.

but raising the ultimate monthly maximum to 270 airplanes in December, 1944.

The tooling problem at Oklahoma City had meanwhile become the facility's #1 problem. The enormous toolmaking burden imposed upon the facility and necessity of producing duplicate sets of tooling for the impending production load was beyond the plant's capacity. The solution of this question was made more difficult because of the shortage of trained tool makers. Partially because of this same problem, the parts supply bins were not filled in the preceding quarter. The parent plant was therefore called upon to assist in overcoming these conditions and it did so by transferring large quantities of components to Oklahoma City.

The insufficient work in process existing during the early portion of this period and the lack of perfect tooling were apparently the principal reasons for company failing to fulfill the schedule of acceptances, but it must be borne in mind that other factors, particularly the unskilled labor situation, also had a contributing effect.

The majority of workmen available at Oklahoma City had had very little machine shop training. As a result, that department fell far behind schedule with many items becoming critical. A similar condition existed in other departments where equally precise workmanship was required. An AAF report in October 1943 made an estimate that 6 months more training would be required before the machine shop production could be brought up to schedule.

Many supervisors and leadmen were in need of considerable more training and experience in order to obtain most efficient output of workers. A large number of qualified supervisors and leadmen transferred from the California plants, were of draft age and eventually inducted into the armed forces.

Transfer of experienced flight ramp mechanics and inspectors to the new modification center was another reason for the failure to keep abreast the original working schedule for this period. On the other hand, the contractor was carrying out extensive and intensive training programs both within and outside the plant.

Engineering changes and airplane modifications were serious disturbing factors during this period, especially in regard to the winterization of the airplanes based on a late conceived deadline date of 1 August, 1943. Due to the manpower situation described above, the additional manhours required for winterization changes necessarily resulted in delays in production.

Numerous GFE items were not received in sufficient quantities, especially landing gear parts and gyro-pilot controls. At one time a shortage of landing gear parts was relieved by the return to Oklahoma City, of 30 airplanes worth of parts misrouted to Long Beach. Considerable difficulty was also experienced because of lack

of receipt of certain critical raw materials, during the spring and summer of 1943.

Subcontracting, especially insofar as one of the principal subcontractors was concerned, was becoming hazardous to the extent that stqbilizers, rudders, elevators and tabs were behind schedule about forty percent. This required special expediting and shifting of operating personnel to avoid delays in airplane acceptances. At the end of this period, factors including even the tooling situation were improving rapidly to the extent that the production lines were filled and, barring unforeseen difficulties, the ensuing schedule for the subsequent months was assured. Although the operation of the production and assembly departments of the plant had improved considerably, and the average Oklahoma workman had demonstrated his adaptability, much remained to be done in integrating these operations and establishing the necessary controls to reach a high productive level. Although production controls were in effect in this period, their refinement and improvement in efficiency were finally to bear fruit in the period of rapid production acceleration which followed.

Final Acceleration Period - (November 1943 to June, 1944 inclusive).

The period of rapid acceleration of C-47 production began in November, 1943 when Oklahoma City had met the revised W8 schedule of 85 acceptances. In the four subsequent months from December through March, production exceeded the goal set in W8 and reached the 250 acceptances originally specified for March in the 8L schedule. Based on the improvement in the facility's performance, the W-9 schedule, issued on 13 January, 1944 increased the sights for the first half of that year to a new peak at 322 airplanes for the month of June. In this six month period, monthly acceptances equalled or exceeded the new schedule.

With the tooling problem in the background, the training programs for manpower had begun to show results. Labor efficiency and utilization both improved although skilled labor in certain categories was still lacking. In December and January the contractor discontinued hiring, which meant that approximately 300 separations were being made weekly with no replacements. Due to the increased schedule, however, the plant resumed hiring again in February. The 8 hour, 7 day work week was made effective 5 months preceding D-Day as requested by the AAF. Immediately following D-Day, the 8 hour, 6 day work week was again resumed.

The improvement in labor utilization and efficiency went hand-in-hand with the perfection of the company's production control system. Although data had been assembled and procedures developed during the preceding months, it was not until beginning of this period that adequate production controls, including controls of material and labor distribution and utilization, based on time studies and other statistics, were made effective. These controls actually affected a man loading rate of approximately 90% of all direct labor, comparing the time charged against operations with that allotted as determined from time study statistics. Computed in like manner,

SCHEDULES & ACCEPTANCES

DOUGLAS - OKLAHOMA CITY

C-47

EXHIBIT NO. 14

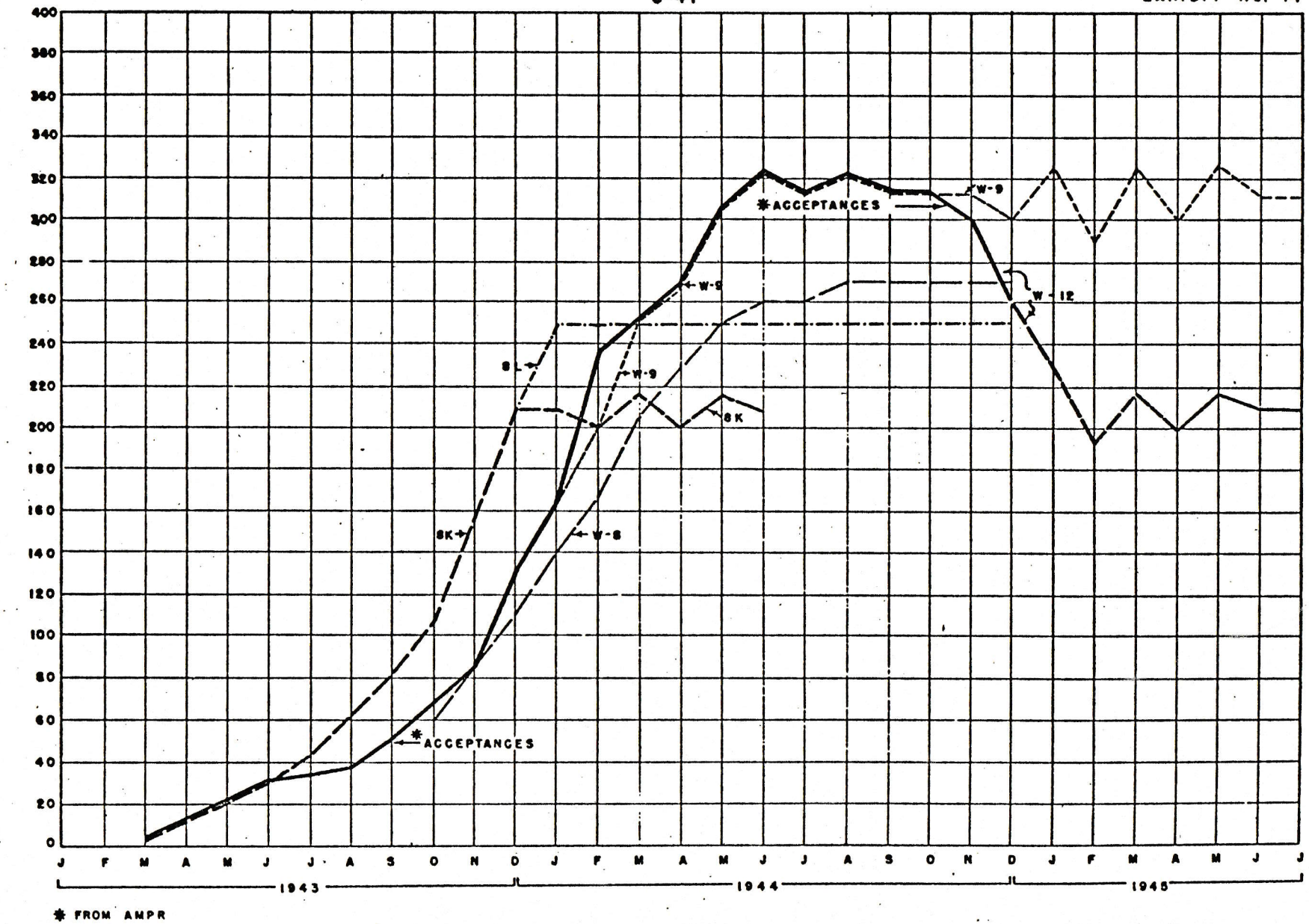


EXHIBIT NO. 14

production equipment was loaded to the extent of approximately 80% of plant operating time. It is apparent, from a study of labor effectiveness as compared with early operations that these improved controls were definitely a major factor in accomplishing rapid production acceleration.

Shortages of GFE and certain critical materials including steel forgings, although corrected to a very great degree, remained a source of difficulty.

During the winter months from November 1943 through January 1944, airplane acceptances were delayed because of inclement weather and certain installations including GFE items. The SCBNA pool grew from 12 in October 1943 to 62 in November, 67 in December and 73 in January 1944. Beginning in February 1944, this pool was gradually reduced to a low of 5 in June 1944. Reference Exhibit #29.

With the above mentioned exceptions, all elements pertaining to manufacturing were adequate and fairly stable. The accumulation of work in process and the experience of personnel during the preceding periods had increased to a point where the operating levels could be maintained and production further increased. Nevertheless, many engineering changes and modifications were still required, necessitating diligent efforts through careful planning to maintain the schedule. These changes are discussed in greater detail under "Engineering". It is pertinent to point out however, that work on one important model change, involving the replacement of the R1830-92 by the R1830-90C engine began in February, 1944 although the change was not accomplished until the following August.

Conclusion

With the acceptance of 322 planes in June, 1944, Oklahoma City reached the peak of its period of rapid acceleration. Production then leveled off for approximately 4 months, after which the facility's output was reduced by the W-12 schedule, reflecting the lower governmental requirements.

SCHEDULES AND ACCEPTANCES

DOUGLAS OKLAHOMA CITY C-47

EXHIBIT NO.15

SCHED-ULE	EFFEC-TIVE DATE	1943										1944												1945					
		M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
S-J	6-11-42			2	10	20	30	40	60	80	109	155	200	210	210	210	210												
S-K	8-7-42	2	11	20	30	43	62	81	106	158	208	208	200	216	200	216	208												
S-L	11-30-42	2	11	20	30	43	62	81	106	158	208	250	250	250	250	250	250	250	250	250	250	250	250						
M-4	6-10-43				30	43	53	70	91	150	198	208	200	224	217	241	240	250	270	260	260	260	250						
M-5	7-15-43					43	53	70	91	150	198	208	200	224	217	241	240	255	270	260	260	260	250						
M-6	8-12-43						53	70	91	150	198	208	200	224	217	241	240	255	270	260	260	260	250						
M-7	9-16-43							58																					
M-8	10-18-43								60	85	110	140	165	206	230	250	260	260	270	270	270	270	270	270	270	270	270	270	270
M-9	1-13-44											164	180	218	224	258	267	266	320	312	312	312	300	324	288	324	300	324	312
M-10	5-13-44														267	306	322	312	320	312	312	312	300	324	288	324	300	324	312
M-11	7-13-44																	312	320	312	312	312	300	324	288	324	300	324	312
M-12	10-12-44																				312	300	260	230	192	216	200	216	208
M-13	1-8-45																							230	192	216	200	216	208
M-14	4-23-45																										299	218	211
M-15	7-13-45																												
ACCEPTANCES		2	11	20	30	33	37	50	67	85	130	164	237	251	267	306	322	312	320	312	312	300	260	230	192	216	200	216	208
CUM. ACCPTNCS.		2	13	33	63	96	133	183	250	335	465	629	866	1117	1384	1690	2012	2324	2644	2956	3268	3568	3828	4058	4250	4466	4666	4882	5090

EXHIBIT NO.15

SCHEDULES & ACCEPTANCES

DOUGLAS - OKLAHOMA CITY

C-47

EXHIBIT NO. 14

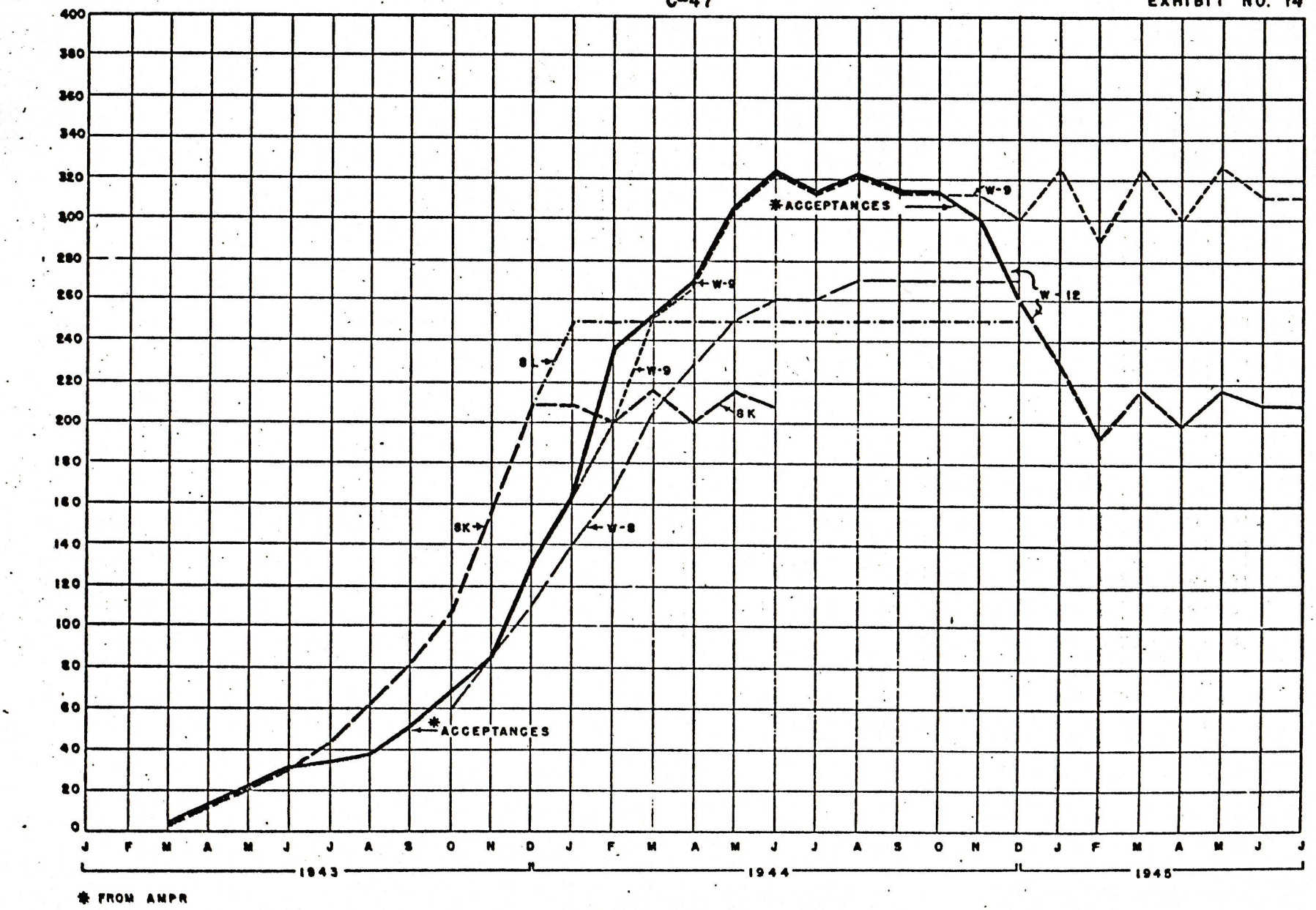


EXHIBIT NO. 14

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With the above mentioned exceptions, all elements pertaining to manufacturing were adequate and fairly stable. The accumulation of work in process and the experience of personnel during the preceding periods had increased to a point where the operating levels could be maintained and production further increased. Nevertheless, many engineering changes and modifications were still required, necessitating diligent efforts through careful planning to maintain the schedule. These changes are discussed in greater detail under "Engineering". It is pertinent to point out however, that work on one important model change, involving the replacement of the R1830-92 by the R1830-90C engine began in February, 1944 although the change was not accomplished until the following August.

Conclusion

With the acceptance of 322 planes in June, 1944, Oklahoma City reached the peak of its period of rapid acceleration. Production then leveled off for approximately 4 months, after which the facility's output was reduced by the W-12 schedule, reflecting the lower governmental requirements.

Production Methods and Tooling

The Douglas Aircraft Company, having had approximately 13 years experience in the manufacture of this type of airplane and having been in production of the C-47 at Long Beach for the AAF approximately 14 months prior to the beginning of production at Oklahoma City, had successfully developed production methods and tooling comparable to anticipated requirements of the Oklahoma City plant. Production methods for Oklahoma City were therefore patterned after those of the Long Beach plant and tooling in duplication of that used at Long Beach was likewise planned for Oklahoma City.

Tooling Plan

In order to facilitate rapid acceleration of production at Oklahoma City, and to assure that both plants would produce interchangeable parts, the Long Beach plant originally proposed furnishing a pilot set of tooling. Oklahoma City would make use of this tooling, not only for production of airplane components, but for use as a guide for production of the additional sets which would be required to complete the tooling program.

Late in 1942, this plan was revised inasmuch as demands subsequently imposed upon the parent toolmaking division became taxed to capacity with other work, resulting in its furnishing of only part of the tooling. This in turn imposed a considerable burden upon Oklahoma City at a time when its toolmaking personnel was not fully trained and its equipment incomplete. It is estimated that only 40% of the major assembly fixtures and accessories for the pilot line was furnished complete and 90% of the remaining portion was furnished in rough form only. Approximately 80% of assembly pilot line tooling was likewise furnished in rough form. Furthermore, the drawings of the unfinished parts were incomplete, necessitating interchange of supplemental data, which obviously caused many delays.

In the original plan, Long Beach was to furnish complete stationary tooling to the Oklahoma City plant. Because of anticipated increased production requirements however, this plan was almost immediately revised and mobile tooling for Oklahoma City was in process of design at Long Beach simultaneously with the preparation of stationary tooling for shipment to Oklahoma City.

Conversion to Mobile Assembly Tooling

As a result of lengthy discussions between Long Beach and Oklahoma City, it was decided that mobile assembly tooling could most advantageously be installed in the Oklahoma City plant before installation at Long Beach. Consequently, the designs were completed at Long Beach and the mobile assembly tooling built at Oklahoma City.

The greater portion of the change-over from stationary to mobile assembly tooling, was accomplished during the period of March through October 1943. Although this change-over while in process, caused some delay in the normal flow of production along the assembly lines affected, it proved to be a very important factor in attaining early production acceleration.

Subcontracting of Tooling

Because of the production time consumed in the manufacture of tooling, the Oklahoma City plant endeavored on numerous occasions to procure tooling from subcontractors. Such efforts were unsuccessful as subcontractors were at that time, operating at full capacity and sufficient priority rating was not granted, to insure on-time delivery. The company's tooling division at Vernon, California was able to render slight assistance by accepting approximately 5% of Oklahoma City's requirements.

One significant case was the subcontracting of a special milling tower for the milling of angles on center wing sections. Approximately 16 months were required to design, construct and deliver this tower due to material shortages experienced by the vendor i.e. the contract was let in August 1942 and delivery made December 1943.

Scope and Personnel

The nucleus of the tooling staff comprising tool designers and toolmakers from the Long Beach facility began operations at Oklahoma City in October 1942. Its activities comprised not only tool production but conducting a training program for potential designers and toolmakers. This training program reached its height in May and June 1943 and was terminated in August of the same year. Trainees comprised both full-time employees of the plant and persons receiving pre-production training. The following is an approximation of the scope of this training program:

Year	Month	Trainees
1942	Dec.	50
1943	Jan.	60
	Feb.	70
	Mar.	90
	Apr.	120
	May	150
	June	150
	July	100
	Aug.	20

Production of tooling began with 521 direct workers, and was gradually increased to 1302 in August 1943, then decreased to 833 at the time peak airplane production was attained. It is estimated that 3,870,000 man-hours were expended in the design, administration and production of tooling, from the beginning of operations October 1942, to peak production in June 1944. Reference Exhibit # 16.

All tooling was substantially complete in October 1943, including the change-over to mobile assembly fixtures. After this date, the major activities of the tooling division were confined to duplications, revisions and maintenance.

Methods

The basic methods of production were developed at Long Beach and

for the most part were common to the industry wherever quantity production was practiced. As new methods were developed and proved by the company or by the industry, they were adopted insofar as was practicable.

Tooling, including jigs, fixtures, templates, gauges, dies, etc., were designed for rigidity and durability, comparable to the quantities and accuracy of the work contemplated. Minor assembly operations were conducted on a combination of static and mobile fixtures. Major sub-assembly and final assembly utilized mobile fixtures which moved intermittently to progressive positions in the production line.

Controls

Time studies, planning and routing of operations were practiced from the beginning but were not made effective to a great extent for several months, as described in detail under "Production Acceleration." These activities gradually developed, however, into a complete production control system by January 1944 and all operations were accurately scheduled and routed by a well established machine and man loading plan based upon careful time studies.

EXHIBIT #16

PRODUCTION OF TOOLING
MAN-HOURS EXPENDED

Year	Mo.	Personnel Adm.	Personnel Design+	Production	Total Man-hours+ (.000)
1942	-	17	30	474	96
1943	Jan	17	30	702	138
	Feb	19	35	923	181
	Mar	21	40	1071	210
	Apr	20	40	1129	220
	May	20	45	1168	230
	June	22	50	1165	243
	July	21	55	1232	250
	Aug	19	60	1242	242
	Sept	26	60	1216	240
	Oct	26	50	1215	238
	Nov	63	40	1192	238
	Dec	62	30	1129	226
1944	Jan	60	30	1036	210
	Feb	61	30	985	198
	Mar	58	25	948	192
	Apr	55	20	903	183
	May	53	20	858	172
	June	52	20	811	163
				Grand Total -	3870

\+ Estimated.

ENGINEERING

Engineering problems pertaining to the C-47 project at Oklahoma City was considerably less than the industry average as the airplane was completely designed, tested and produced in the parent Long Beach plant prior to its manufacture at Oklahoma City. Prior to July 1944, engineering data was retained at Long Beach for the express purpose of maintaining complete interchangeability of parts. Although certain engineering changes and revisions could have been handled more expeditiously at Oklahoma City, the transmittal of engineering data to Oklahoma City and the close cooperation maintained between the two facilities proved invaluable to the Oklahoma City operation. All drawings, changes and revisions were identified by the same number in both the Long Beach and Oklahoma City plants, thus preventing duplication of work and aiding the interchangeability of parts. Upon the completion of C-47 contracts at Long Beach in July 1944, all engineering data and responsibilities were transferred to Oklahoma City.

Due to the variations in use of the C-47 airplane, extensive modification changes were made. During the early production period, modification changes consumed a considerable portion of engineering and production time. Beginning in July 1943, modifications were accomplished in the newly constructed modification center adjacent to the plant.

Engineering personnel at Oklahoma City was originally formed from a small nucleus of 12 to 15 persons transferred from the Long Beach plant during October 1942. The engineering department developed to approximately 125 persons as production acceleration increased.

All engineering activities pertaining to engineering changes and modifications, and as related to tooling and production methods, was in the beginning, under the jurisdiction of a nucleus staff of engineers provided by the parent plant in October 1942. This staff quickly developed into an organization of approximately 115 engineers as of November 1942, which was maintained until peak production requirements were accomplished.

The policy requiring that design engineering remain with the parent plant was adhered to even though some changes in design might have been handled more expeditiously by Oklahoma City, but with the attending hazards of non-interchangeability of parts and inadequate overall scheduling.

All engineering drawings were made and all engineering changes controlled from the Long Beach Plant, and transparents and other necessary data forwarded to Oklahoma City. Drawings and engineering changes were identified by the same number in both the Long Beach and Oklahoma City plants, thus preventing duplication of work and aiding in the interchangeability of parts. This procedure was maintained until July 1944, at which time because of completion of C-47 contracts at Long Beach, engineering responsibility for this plane was transferred from Long Beach to the Oklahoma City engineering department.

Engineering Changes

A total of 308 engineering changes were incorporated in the C-47 airplane at Oklahoma City. Of these changes, 83 were engineered in the Long Beach plant and 225 in the Oklahoma City plant. Because of the previous production of this airplane at Long Beach and the cooperation maintained between Long Beach and Oklahoma City, a comparatively small number of engineering changes were required and a minimum of difficulty experienced in their accomplishment.

Drawing Changes

Although drawings received from Long Beach were up-to-date at time of completion, it became necessary, due to the urgency of the occasion; to make numerous changes and revisions at Oklahoma City, without waiting for Long Beach coordination.

During the first year of operation, the Oklahoma City plant, frequently placed new tooling in service without running trial parts, which procedure necessitated many additional drawing changes and caused confusion in certain production departments.

These situations temporarily caused non-interchangeability of certain parts and although substantially corrected early in 1944, necessitated continual vigilance in the effort to maintain up-to-date drawings and interchangeability of parts without retarding the normal flow of production.

Conclusion

Although numerous obstacles were encountered due to the urgency of the occasion and lack of preparedness for rapid production acceleration, no delays in airplane acceptances can be attributed to engineering.

MACHINE TOOLS AND PRODUCTION EQUIPMENT

The original facility project including the procurement and installation of all machine tools and production equipment, was under supervision of the U. S. Corps of Engineers. Allocation of the funds expended for same, as reported by the U. S. Corps of Engineers to the Industrial Facilities Branch ATSC, 22 June 1944, were as follows:

Machine tools	$ 5,985,829.86
Portable tools.	672,320.92
Automotive equipment.	481,633.81
Other production equipment. . . .	609,752.02
	$ 7,749,536.61

The Plan

It was planned that the anticipated demands of machine tools and production equipment should be based upon experience gained in the Long Beach plant and that all purchase orders be placed with the U. S. Corps of Engineers at the earliest possible date, to insure the beginning of installations within the new plant during July 1942. As delays in building construction were encountered, this plan was revised to include the installation of machine tools in warehouses for the early training of personnel.

Receipts and Installations of Machine Tools and Production Equipment

Because of the delay of approximately 4 months in building completion, early receivals of machine tools were set up in a downtown warehouse and advantageously used for training and production purposes. These machines were transferred to the plant as rapidly as building construction permitted. Although some difficulty was experienced in receipt of certain production equipment, the major portion of all such equipment was received in due time for installation concurrently with building construction progress.

Actual receival dates of machinery of specific types and quantities cannot at this time be accurately determined, but an estimate of all machinery delivered, including administrative equipment, during each of the several months is shown by Exhibit #17. This indicates that had the originally needed specific machines or equipment been received on the dates specified in the schedules, few, if any, production delays could be attributed to late deliveries, especially in view of the retarded tooling program. When machinery was not received on schedule it was necessary to employ ingenious methods to maintain production. On other occasions machinery was received before it could be installed in the space allotted because the building construction was not far enough advanced.

In order to assist in the receipt of machine tools and other equipment as needed, an extensive expediting program was instituted by the company. It was only moderately successful. There were cases in which special transportation was employed to expedite deliveries and in other cases materials were shipped to other facilities for

processing pending receipt of company's own machinery. A specific case is that of one twenty-five ton hydro-press having been scheduled for receipt in May 1943 but it was not received until January 1944. This condition necessitated materials and components being shipped to the Long Beach facility for processing, a suitable press having had machine time open there. This procedure prevailed during the full six months intervening period, and obviously contributed to lowering operating efficiency at Oklahoma City. This was a period of scheduled low production, but had it occurred during a period of high production more serious delays would have resulted.

There were many other instances of like nature, but as in this case, by the alertness and ingenuity of company personnel, the program for machine tool and other production equipment kept pace with all other phases of manufacturing so that no delays in airplane acceptances can be directly attributed to the lack of such items.

EXHIBIT #17

CAPITAL EQUIPMENT
(Including Machine Tools, Production Equipment & Office Equipment)

SCHEDULE OF RECEIVALS

Year	Month	Percent of Total Value
1942	Prior to November	18.0
	December	21.9
1943	January	29.8
	February	36.5
	March	43.8
	April	52.1
	May	54.2
	June	65.1
	July	69.4
	August	70.5
	September	71.6
	October	73.8
	November	73.8
	December	83.2
1944	January	92.1
	February	97.0
	March	98.1
	April	99.2

MATERIALS AND PURCHASED PARTS

The difficulties of procuring on-time delivery of materials and commercial components were of serious concern in connection with the rapid production acceleration. This condition prevailed by reason of materials peculiar to aircraft, particularly aluminum and many grades of alloy steel items were very scarce inasmuch as they had limited use in industry prior to World War II and therefore, an unprecedented burden was imposed upon the unprepared materials producers. This situation was aggravated by maldistribution among airplane manufacturers who could not accurately predict their requirements, especially prior to 1944. The condition was further affected by the inadequate national control of material distribution.

Douglas, Oklahoma City, like most other producers, estimated its requirements optimistically in order to assure their obtaining full quantities of all items as scheduled. This resulted in unbalanced inventories consisting of excessive quantities of some items and a scarcity of others. As the national situation became more stabilized, and controls made more effective, the company's stocks were brought within a practical working inventory. This situation was still further improved during February 1944 due to the company's revised material control system which maintained very close coordination among all departments concerned.

Procurement

Procurement difficulties at Oklahoma City were considerably lessened because of experience gained by the parent Long Beach plant and the receival of 75 knock-down airframes from the Long Beach plant. Although special efforts were made to place purchase orders sufficiently in advance of scheduled requirements to permit on-time receivals, numerous unanticipated difficulties resulted as explained in the succeeding paragraphs.

Critical shortages of materials although considerably alleviated during the latter part of 1944, remained a constant source of difficulty throughout the entire production period. Some of the principal items involved were alloy steel and aluminum forgings during the summer of 1943; bearings, elastic stop nuts and electric motors from late 1942 to the latter part of 1944; plywood from the summer of 1943 throughout the production period, and all textiles from the beginning to the end of operations. Such shortages necessitated extensive expediting by a large staff of company personnel, and in many cases by the assistance of the AAF through its ASU-16 procedure.

There were numerous occasions wherein it was impossible for the company to forecast its materials requirements sufficiently far in advance to permit vendors to make on-time deliveries. For example, with no precedence upon which to base estimates, the AAF could not anticipate spare parts requirements accurately, and therefore would specify spare parts in dollar value only without scheduling by part numbers or quantities. Scheduling would follow later requiring that specific spare parts be shipped concurrently with the related airplanes or ahead of the airplane schedule. Dates specified for parts

making it necessary to divert materials, components or assemblies intended for airplanes to spares. This not only disturbed an even flow of production but caused serious material shortages.

Conclusion

Difficulties in the procurement and storing of materials and purchased parts during the early production period were considerably lessened because of experience gained in the parent Long Beach plant. The inability of vendors to ship as scheduled, resulted in unbalanced stocks in the Oklahoma City plant and necessitated a more effective material control system. Shortages of certain critical materials remained a constant source of difficulty throughout the entire production period.

EXHIBIT #18

VENDORS - PARTIAL LIST

Castings -

A & F Alum. Products Co., Los Angeles, Calif.
Acme Pattern & Foundry Company, Maywood, Calif.
Aero Alloys, Vernon, Calif.
Aluminum Co. of America, Los Angeles, Calif.
Compton Metals Co., Compton, Calif.
Arrow Brass Foundry, Los Angeles, Calif.

Forgings -

Aircraft Mechanics, Inc., Colorado Springs, Colo.
Ajax Forge Co., Inc., Los Angeles, Calif.
Billings & Spencer Co., Hartford, Conn.
Bohn Aluminum & Brass Corp., Detroit, Mich.
Chevrolet, Muncie, Indiana
General Metals Corp., Los Angeles, Calif.
Kropp Forge Co., Chicago, Ill.
Ladish Drop Forge Co., Cudahy, Wisc.

Screw Machine Products -

Dill Manufacturing Co., Cleveland, Ohio
Lamson & Sessions Co., Cleveland, Ohio
National Lock Co., Rockford, Ill.
Rockford Screw Products Co., Rockford, Ill.
Thompson Products, Inc., Bell, Calif.

Bearings and Gears -

Boston Gear Works, Inc., North Quincy, Mass.
Bound Brook Oil-Less Bearing Co., Bound Brook, N. J.
Chrysler Corp., Detroit, Mich.
Fafnir Bearing Co., New Britain, Conn.
Nice Ball Bearing Co., Philadelphia, Pa.
S.K.F. Industries, Inc., San Francisco, Calif.

Hydraulic Hose, Fittings and Assemblies -

Aero Coupling Corp., Burbank, Calif.
Chicago Metal Hose Corp., Maywood, Ill.
Deutsch Co., Kansas City, Mo.
Dole Valve Co., Chicago, Ill.
J. F. Dixon Co., Los Angeles, Calif.

Hyd. Hose, Fittings & Assys. (Cont'd) -

Lunkenheimer Co., Cincinnati, Ohio
Pacific Pumps, Inc., Huntington Park, Calif.
Parker Appliance Co., Cleveland, Ohio
Saval Co., Los Angeles, Calif.
Smith Meter Co., Los Angeles, Calif.
Weatherhead Co., Cleveland, Ohio
Williams Automatic Heating Co., Bloomington, Ill.

Electrical Accessories -

Adams & Westlake Co., Elkhart, Ind.
Allen Bradley Co., Milwaukee, Wisc.
American Phenolic Corp., Cicero, Ill.
Bendix Prod. Div., South Bend, Ind.
Cutler Hammer Mfg. Co., Milwaukee, Wisc.
Electronic Laboratories, Inc., Indianapolis, Ind.
Harwood Co., Los Angeles, Calif.
Leach Relay Company, Inc., Los Angeles, Calif.
Lights, Inc., Alhambra, Calif.
P. R. Mallory & Co., Inc., Indianapolis, Ind.
Micro Switch Corp., Freeport, Ill.
Monarch Tool & Instrument Co., San Diego, Calif.
Ohmite Manufacturing Co., Chicago, Ill.
Poulson & Nardon, Inc., Vernon, Calif.
Square D Company, Detroit, Mich.

Fire Extinguishers, Heaters, and De-icers -

Walter Kidde & Co., Inc., Belleville, N. J.
Pyrene Mfg. Co., Newark, N. J.
Raymond De-Icer Co., Inc., Los Angeles, Calif.
Stewart Warner Corp., Chicago, Ill.
Parachute Corp. of America, Los Angeles, Calif.

GOVERNMENT FURNISHED EQUIPMENT

An effective organization was established immediately upon beginning of operations at Oklahoma City for the control of GFE and by diligent cooperation with the AAF personnel all anticipated requirements were scheduled early. When late shipments became apparent they were immediately expedited, with the result that actual shortages were not so serious as to retard airplane acceptances.

Inventory

The original plan contemplated maintaining a thirty day supply of all items. This was carried through to the extent of eighty percent of the number of items, necessitating expediting the balance to maintain a working inventory. This was a healthy condition, considering the demands for similar products placed upon GFE producers by a large number of contractors, with variable and sometimes unsound scheduling practices. The result was that some contractor's inventories were very erratic, thereby causing maldistribution of products. Scheduling of GFE at the Oklahoma City plant was considered good.

Reconditioning of Defective Items

With few exceptions, government furnished equipment was received in good condition and ready for installation. These few exceptions required replacement of defective accessories or minor reworking, usually resulting from damage in transit or handling. The government required all defective or damaged GFE to be returned to the producer or a GFE depot for repairs. As GFE stocks were usually kept at a minimum in the contractor's plant, the practice of returning defective or damaged items for repairs, frequently resulted in a shortage of the contractor's supply and delayed production. Had the government permitted the contractor, under close supervision, to make minor repairs on GFE, much time could have been saved and such delays in production prevented. Reference Exhibit #19.

Conclusion

The experience record in the procurement and use of government furnished equipment at this facility was quite satisfactory. Approximately 600 items of such equipment were incorporated in the C-47, which represented about forty percent of the cost of the plane.

Personnel of both the contractor and the AAF contributed materially to the success of the GFE program by their serious efforts to schedule accurately and to control GFE deliveries.

EXHIBIT #19

ITEMS OF GFE

Name of Assembly	Quantity of Items Per Assembly		
	Quantity of Assemblies	Items Per Assembly	Quantity of Items
Propeller	2	6	12
Power Plant	2	2	2
Pumps	4	1	4
Armament	6	6	46
Oxygen Equipment	14	14	70
Instruments	37	37	50
Electrical Equipment	28	28	61
Misc. (Incl. Supply Div.)	13	13	24
Landing Gear	4	4	6
Radio Equipment	71	255	326
TOTAL	181	366	601

SUBCONTRACTING

At the time this facility began operations and until August 1944, the Long Beach plant was producing the same model airplane. Therefore, it was good practice, in order to facilitate subcontracting, for the parent plant to procure subcontracted items for Oklahoma City, insofar as was practicable, from existing suppliers already manufacturing these items. Accordingly, the Long Beach plant directed its subcontractors to also supply Oklahoma City.

Operations and Procedures

Subcontracting at Oklahoma City involved approximately 100 suppliers. The percentage of direct man-hours per airframe unit charged to outside production is reported by aeronautical monthly progress reports, ranged from 53% in February 1943 to 16% in August 1943, to 18% in Aug. 1944 and remained approximately 18% throughout the remainder of the production period. Reference, Exhibit # 37.

Two major subcontractors produced the most substantial portion of the work, namely; Pullman Standard Car Manufacturing Company, Aircraft Division, Chicago, Illinois, furnishing the outer wing assemblies, and the McDonnell Aircraft Company, St. Louis, Missouri, furnishing the empennage assemblies.

It is estimated that less than 10% of total airplane materials and production equipment was furnished to vendors to be incorporated into, or used to produce, products for the prime contractor.

The parent plant was solely responsible for materials, tooling, production methods and quality workmanship of the subcontractors during the entire production period of the Oklahoma City facility. However, Oklahoma City personnel acted as liaison for Long Beach and subcontractors in this matter.

The quality of all subcontracted items was of a very high average. Delays encountered in production were few and of minor consequence, due to careful planning and controll of all operations by the parent plant, assisted by the subsidiary plant. For the more important items subcontracted, see Exhibit # 20.

Difficulties Encountered

The usual production difficulties were encountered necessitating engineering and manufacturing assistance to the subcontractors, assistance in expediting deliveries of materials and production equipment, and in maintaining uniform products. These were minimized, however, as the result of experience previously acquired by the subcontractors in having supplied similar products to the parent facility.

Conclusion

The success of this subcontracting program not only contributed to early airplane acceptances but assisted materially in the rapid acceleration of production. Supervision by the parent plant made possible this success.

EXHIBIT #20

MAJOR ITEMS SUBCONTRACTED

Outer wings
Wing tips
Ailerons
Aileron flap
Wing flaps
Outer wing flaps
Horizontal stabilizer
Vertical stabilizer
Elevator assembly
Rudder assembly
Tab rudder assembly
Tab elevator assembly
Cowl flaps
Cowl flap support
Cowl flap valve
Tanks
Tank cradles
Ferry tanks
Loading ramps
Exhaust collector rings
Controls
Motor mount tubes
Air cleaners
Cylinder assembly
Flap relief valve
Pumps and valves
Pump assembly
Four way valve assembly
Valve hydraulic selector
Retract strut cylinder assembly
Strut assembly wing flap
Tube assembly brake torque
Rudder pedals
Pedal assembly
Hydraulic assemblies
Hydraulic hose assembly
Tail pipes
Shock mounts
Shock struts
Troop seats
Rudder stocks
Landing gear truss
Castings and forgings
Doors

INSPECTION

As in the majority of cases during the early part of our experience in World War II, the demand for rapid production acceleration far exceeded the availability of trained inspection personnel. Although basic inspection difficulties at the Oklahoma City plant have been attributed to this situation, and quality control remained "B" classification from 6 March 1943 to the end of the production period, no delay in the acceptance of airplanes can be directly attributed to any phase of inspection procedures.

Growth of the Inspection Department

The inspection department at Oklahoma City was developed from a nucleus of 32 inspectors transferred from the Douglas, Long Beach and Santa Monica plants during the latter part of 1942. These men, with an average experience of 5 to 7 years each, acted as instructors in trade schools and in the plant, and formed a nucleus of supervisory personnel.

Two sources of training were established prior to completion of building construction, one in the Agriculture and Mechanical College at Stillwater, Oklahoma, in September 1942, the other, a trade school set up in a warehouse in Oklahoma City in October 1942. Both were Government sponsored and had a combined student capacity of approximately 400 persons. The major portion of inspectors graduated were directly employed by Douglas Aircraft. They were, all instrumental however, in inspection of the C-47 airplane, due to the fact that those not employed by Douglas were employed by subcontractors in the vicinity.

Instruction courses were for a period of 40 days and the curriculum adequately covered the entire inspection field as applied to the manufacture of C-47 airplanes. It was discovered later, however, that due to highly specialized instruction and individual aptitudes, many persons completing the training course were lacking in the versatility necessary for inspection work on numerous components or assemblies, necessitating considerable on-the-job instruction.

The training of Army Air Force inspectors was conducted at the facility by the inspector in charge and consisted of approximately 6 weeks instruction followed by actual on-the-job training, until such time as the individual became qualified for the position to which he was assigned.

Although operations of the contractor's inspection department did not at all times keep pace with increased production acceleration, the percentage of contractor inspection personnel as compared with direct workers, indicates a gradual increase in efficiency as is shown in the following tabulation.

Date	Direct Workers	Contractor Inspectors	% Contractor Inspectors to Direct Workers	AAF Inspectors
7-1-43	7884	920	11.7%	78
1-1-44	11762	950	8. %	115
7-1-44	12107	929	7.7%	123
1-1-45	9330	718	7.7%	110
7-1-45	8807	650	7.4%	70

Major Factors in Inspection Control

The problem of obtaining complete unanimity of policies and procedures between the Army Air Forces and contractor's inspectors, although gradually improved, was never entirely accomplished. This is indicated by the quality control classifications issued, viz., Class "C" from November, 1942, the beginning of the production period until April 1943, and Class "B" from that time to the end of the entire production period.

The principal causes for not achieving quality control classification "A" are as follows:

1. The large quantity of inspection personnel requiring close supervision and on-the-job training. This situation, although showing gradual improvement, existed throughout the major portion of the production period.

2. Unproven and incomplete tooling received from Long Beach, caused rejection of thousands of component parts prior to October 1943.

3. Errors in receiving inspection, e.g., the acceptance of non-usable ailerons from Pullman Standard Car Company during the summer of 1943.

4. Inaccurate inspection on detail sub-assemblies used in the center wing sections, prior to April 1944.

5. The removal of rivets in the center wing spars, by rivet guns and chisels thus elongating and damaging the rivet holes. Such practice continued until the latter part of 1943.

6. The occasional rejection of completed airplanes due to the quantity of squawks and especially difficulties with the installation of radio and electrical equipment.

The contractor's executive personnel cooperated most cordially with the Army Air Forces in the major phases of inspection procedures throughout the entire production period, the most important of which were the following:

1. Cooperation in the training of new employees.
2. Contractor maintained suitable system for identification of raw materials.
3. Contractor supplied adequate precision instruments for the inspection of gauges, templates, and fixtures.
4. Contractor maintained adequate magnetic inspection equipment.
5. Contractor obtained use of the X-ray equipment of Industrial Laboratories, Dallas, Texas.
6. The setting up of a salvage board, April 1943.

The contractor's inspection equipment was checked for accuracy per

Army Air Force requirements on the following basis:

Master gauges	30 days
Reference gauges	30 days
Master templates	Continuously
Reference templates	30 days
Shop templates	When reworked
Shop fixtures	Weekly

The contractor's improved production methods during the early part of 1944 were especially helpful to the inspection department. The most important of these were:

1. Thorough inspection of all first-run items.
2. Increased accuracy in inspection of detail sub-assemblies, especially those used in center wing sections.
3. Use of drills for removal of rivets in center wing section.
4. The installation of improved time study methods.
5. The shifting of certain personnel to the departments in which they were most efficient.

Presentation of Army and Navy Awards

Although airplane acceptances were on or, ahead of schedule after September 1943 and reached an all-time high of 322 in June 1944, quality control improved to the extent that the Army and Navy "E" Award was presented in September 1944 and the "E" Star" Award, in March 1945.

MANPOWER

Summary

From the standpoint of manpower resources, Oklahoma City was an ideal region for the production of aircraft. The city had a population of 204,000 in 1940 and during the course of the war it increased only 50,000. It is obvious, therefore, that the influx was below that which could be expected for the increase in number of workers required by the war effort, and that the ultimate employment of about 22,500 by the Douglas Company was drawn largely from permanent residents living in the local and surrounding areas. The objective of tapping a potential labor market was, therefore, accomplished in constructing the new facility in this location.

Because the region was predominately agricultural, persons with skills readily adaptable to the aircraft manufacturing industry were in the extreme minority, necessitating the establishment of government sponsored trade schools.

Direct workers were employed as rapidly as pre-production trade school courses were completed and personnel requirements established. When possible, all new workers were given in-plant training prior to direct assignment to production positions. Employees were advanced to work requiring greater skills as their talents warranted, and in due course, a well balanced production force was developed. This was accomplished by the combined efforts of the nucleus organization of management, engineering and production personnel transferred from the company's other facilities and by the efforts of government sponsored educational institutions. Labor itself manifested willingness, energy, and a spirit of cooperation, with the result that the job was completed without interruption due to any strain in management-labor relations.

The Plan

The management being fully aware of the type and quantity of available workers in the Oklahoma City area, recognized the need for early establishment of pre-employment training courses and cooperated with the state department of education, operating under the National Vocational Program in regard to the estimated number of trainees and the required curriculum.

The number of workers required and the rate of hires were estimated from statistics compiled from experience gained in the Long Beach plant, with due consideration given the acquired skills at Long Beach and the lack of such skills in the Oklahoma City area.

Recruiting of Workers

The personnel manager and assistants transferred from the Santa Monica and Long Beach plants arrived in Oklahoma City in July 1942, and immediately initiated a campaign for recruiting workers. All conventional methods were used to interest applicants, and included newspaper and billboard advertising, radio appeals, contacts by mail, telegrams and telephone calls. Experience disclosed, however, that the most effective method was by personal letters to potential applicants. An unusual method of recruiting applicants was by making house to house canvasses, but this was resorted to only during the most critical periods. Another unusual and particularly successful way of interesting workers was to invite them to the plant that they could observe the kind of work expected of them. This was effective because many people had the opinion they could not adapt themselves to mechanical work. The result in most cases was that they then realized the work was within their ability and proceeded to make application.

The acquiring of a qualified labor force of sufficient quantity proved to be a comparatively slow process, especially during the first 8 months of production when considerable difficulty was experienced because of lack of machinists, tool designers and tool workers.

The referral of new employees from the United States Employment Service was helpful but produced only a very small percentage of the required personnel, due largely to the contractor's efficient recruiting program; the transferral of workers from trade schools to the plant and the United States Employment Service system of referring skilled workers to employers in other areas who had received higher priorities for personnel requirements.

With the exception of about 600 workers transferred from the company's other facilities (51% from Santa Monica, 46% from Long Beach and 3% from El Segundo), fully 75% of all workers were recruited from within a 70 mile radius of Oklahoma City. Recruiting began in September 1942 at a temporary office in Oklahoma City. By March 1943, 9,846 employees were on the payroll and by June of the same year this number was increased to 15,791. Peak employment was in November 1943, when a total of 22,549 was reached. Accessions were high until July 1943, during which month 3,559 workers were hired; thereafter accessions declined rapidly until December when only 94 hires were made. Monthly separations varied from 3% of total employment at the start of production to 7 1/2% or 1,679 in June 1944 when peak production was achieved. Female workers numbered about 50% of total employment throughout the entire production period. As of 1 July 1945, a total of 1,603 employees entered

the Armed Forces. This was considerably less than the industry average due to efforts of the contractor to employ persons beyond draft age.

Training

Trade schools established in and near Oklahoma City for the purpose of training aircraft manufacturing personnel, were functioning effectively in November 1942. Certain experienced personnel transferred from the Douglas Aircraft Company's California plants formed a nucleus of instructors for such trade schools. Many of these schools, especially the National Defense Training Schools sponsored by the State Labor Department, were of outstanding assistance to the industry, their equipment was up to date and their curriculum sufficiently diversified. The courses of instruction were usually of six weeks duration after which, trainees employed by Douglas, were given actual in-plant training until such time as they were considered qualified to successfully accomplish the work assigned.

For the purpose of improving in-plant training, many manufacturing operations were broken down to the extent that individual aptitude could be most advantageously utilized. Workers were advanced to more difficult operations in accordance with their improved skills and to supervisory positions after sufficiently demonstrating their capabilities, providing the need arose. Special courses in supervisory training were sponsored by the Engineering, Science and Management War Training Program assisted by Douglas Aircraft Company. Approximately 4,000 persons enrolled for supervisory training courses during the production period.

Work-Week and Shift Distribution

The plant operated on a 3 shift basis, each shift working 48 hours per week. The first shift comprised the most workers but the second totalled approximately 90% of the first shift. The third shift varied greatly in number of workers from about 7% to as high as 55% of the number on the first shift. This variation was caused by several reasons, the principal one of which was the uncontrollable work load imposed by reason of this shift being utilized to a great extent during the early months of production, to balance the production of the first and second shifts. Reference Exhibit No. 29.

The three shift method proved to be ideal not only because of the part the third shift played during the early production period, but also due to the fact that this shift was trained and made ready during this period to take its share of the production load during the later months of operation when the planned capacity of the facility was exceeded by about 30%.

Labor-Management Relations

Because of management's efforts to give all possible assistance to workers and the over-all atitude of the workers to put forth an all-out effort to win the war, there were no serious disagreements between labor and management, no strikes and no work stoppages during the entire production period. A very high morale and a splendid spirit of cooperation existed in the entire labor organization.

After several attempts were made by labor organizational groups to negotiate for the workers, either by craft or factory representation, the UAW-CIO became the sole labor bargaining agency. The UAW was voted down in April 1944 but received a majority vote in March 1945.

Labor Utilization

As originally planned, the labor organization was developed from experience gained in the Long Beach plant, with careful consideration given the necessary training requirements and readjustments of persons previously engaged in occupations foreign to the aircraft industry.

Following the trend of the industry, labor utilization was considerably improved after the first 8 to 10 months operation, and direct man-hours per unit were gradually lessened until peak production was reached. Reference Exhibits No. 32 and No. 37.

During the first 8 months of operation considerable difficulty was experienced due to lack of sufficient quantity of skilled workers, the more important of which were machinists, tool designers and tool makers. Production schedules were usually met despite the shortage of skilled workers, as a result of detailed break downs of the job followed closely by time studies and methods analyses to accomplish proper sequential loading and balance of manpower requirements.

A synchronized and balanced load definitely improved the morale of all employees as the contractor carefully avoided overloading departments temporarily short of experienced personnel. Detailed time studies enabled supervisors to work out equitable production assignments and were of valuable assistance in the grading and classifying of workers. One of the latest and most important improvements in labor utilization was made in the center wing section of the sub-assembly lines, early in 1944.

EMPLOYMENT–TOTAL DIRECT AND TOTAL FEMALE

DOUGLAS–OKLAHOMA CITY

C-47

EXHIBIT NO21

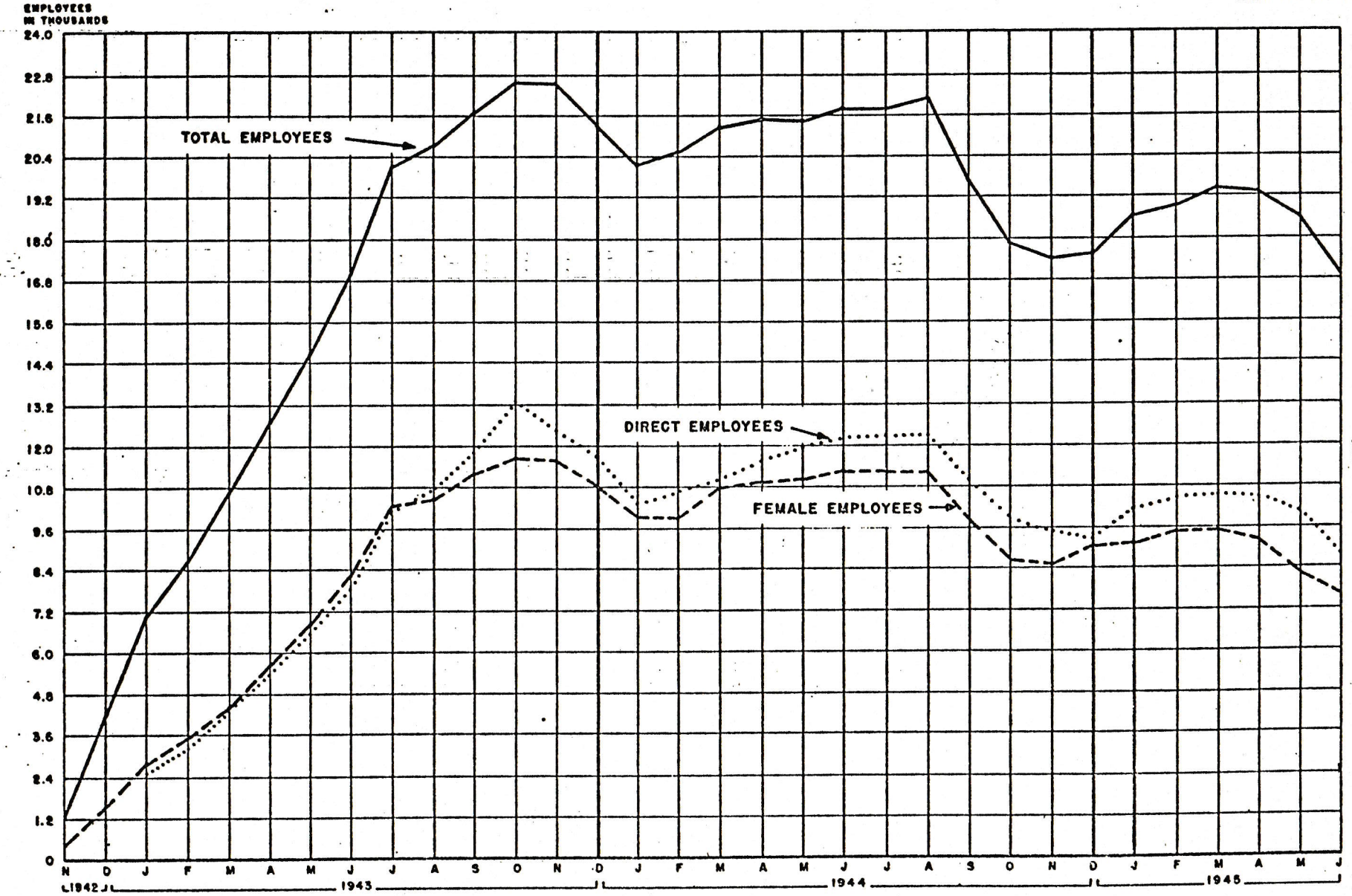


EXHIBIT NO21

TURNOVER – ACCESSIONS – SEPARATIONS

DOUGLAS – OKLAHOMA CITY

C-47

EXHIBIT NO.22

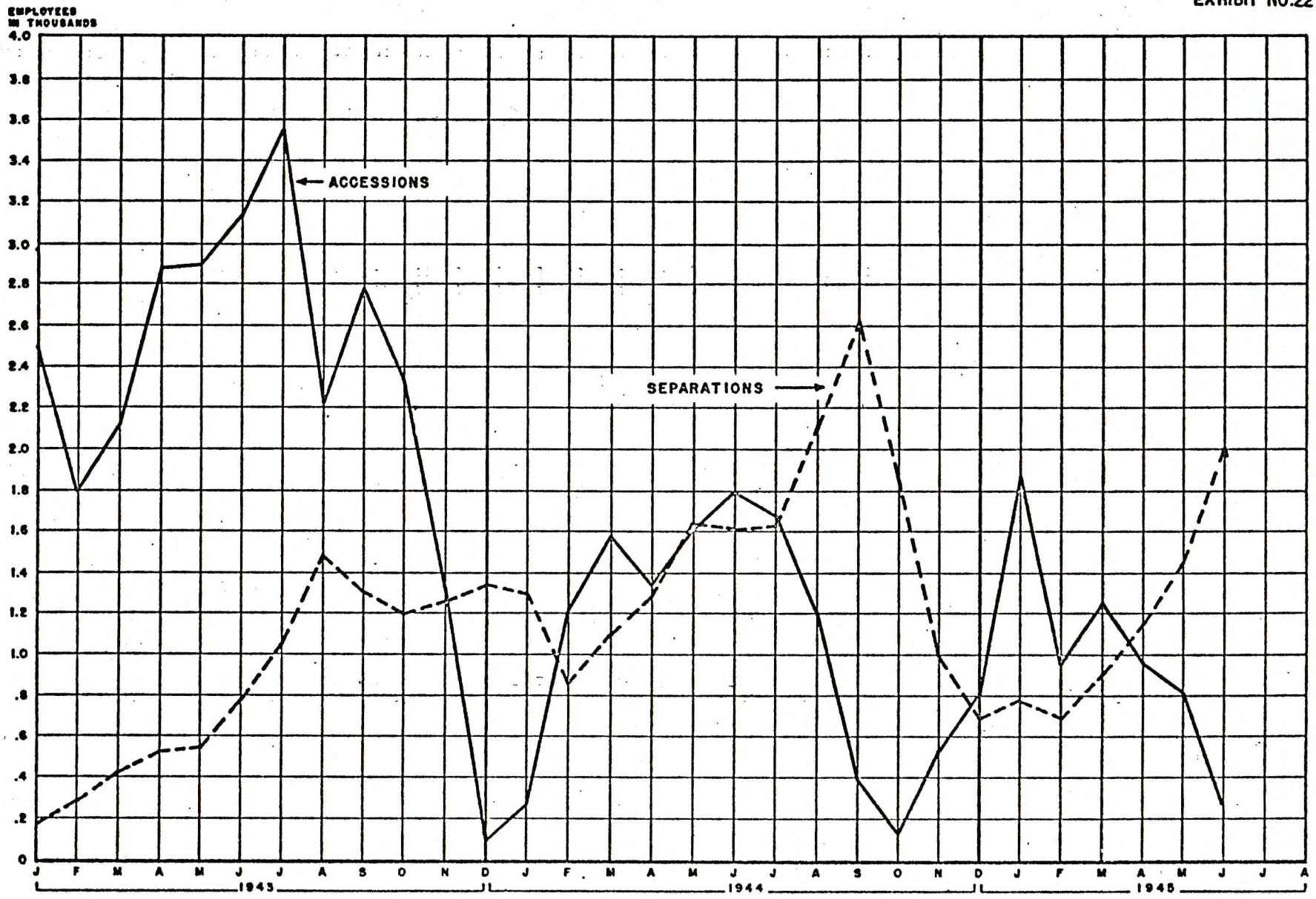


EXHIBIT NO.22

EMPLOYMENT & TURNOVER

DOUGLAS OKLAHOMA CITY C-47

ÆXHIBIT NO.23

		GROSS EMPLOYMENT					NET EMPLOYMENT									TURNOVER						
		TOTAL		FEMALE			TOTAL		DIRECT				INDIRECT			ACCESSIONS		SEPARATION		NET ACCESSIONS		% O.P.
		NO.	NET CHANGE	NO.	NET CHANGE	% TOTAL	NO	NET CHANGE	NO.	NET CHANGE ACTUAL	NET CHANGE RATE	% TOTAL	NO.	NET CHANGE	ACCESS. RATE	ACTUAL	RATE	ACTUAL	RATE	ACTUAL	RATE	
		1.	2.	3.	4.	5	6.	7.	8	9	10	11.	12.	13	14	15	16	17	18	19	20	21
42	NOV.	1360	NR	433	NR	31.8	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	DEC.	4313	+2953	1567	+1134	36.3	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
1943	JAN.	7071	+2758	2740	+1173	38.7	"	"	2483	"	"	35.1	4588	"	"	2508	40.9	185	3.0	+2323	+37.9	"
	FEB.	8648	+1577	3500	+760	40.5	"	"	3208	+725	+29.2	37.1	5440	+852	+18.6	1801	22.3	292	3.6	+1509	+18.7	53
	MAR.	10565	+1917	4460	+960	42.2	"	"	4300	+1092	+34.0	40.7	6265	+825	+15.2	2123	21.9	428	4.4	+1695	+17.5	53
	APR.	12734	+2169	5650	+1190	44.4	"	"	5350	+1050	+24.4	42.0	7384	+1119	+17.9	2891	24.7	533	4.6	+2358	+20.1	53
	MAY.	14701	+1967	6810	+1160	46.3	"	"	6550	+1200	+22.4	44.6	8151	+767	+10.4	2899	20.8	554	3.9	+2345	+16.7	53
	JUN.	17027	+2326	8280	+1470	48.6	"	"	7900	+1350	+20.6	46.4	9127	+976	+12.0	3156	19.2	784	4.8	+2372	+14.4	53
	JUL.	20141	+3114	10310	+2030	51.2	"	"	10100	+2200	+27.8	50.1	10041	+914	+10.0	3559	18.8	1053	5.6	+2506	+13.2	34
	AUG.	20740	+599	10520	+210	50.7	"	"	10700	+600	+5.9	51.6	10040	-1	-.01	2231	10.9	1484	7.2	+747	+3.7	16
	SEP.	21795	+1055	11200	+680	51.4	"	"	11750	+1050	+9.8	53.9	10045	+5	-.05	2778	12.8	1313	6.1	+1465	+6.7	16
	OCT.	22647	+852	11710	+510	51.7	"	"	13250	+1500	+12.8	58.5	9397	-648	-6.5	2336	10.6	1200	5.4	+1136	+5.2	16
	NOV.	22594	-53	11670	-40	51.6	"	"	12468	-782	-5.9	55.2	10126	+729	+7.8	1336	5.9	1258	5.6	+78	+0.3	16
	DEC.	21423	-1171	10850	-820	50.6	"	"	11762	-706	-5.7	54.9	9661	-465	-4.6	94	0.4	1347	6.1	-1253	-5.7	16
1944	JAN.	20257	-1166	10061	-789	49.7	19088	"	10333	-1429	-12.1	54.1	8755	-906	-9.4	271	1.2	1302	5.9	-1031	-4.7	16
	FEB.	20556	+299	10048	-13	48.9	19334	+246	10718	+385	+3.7	55.4	8616	-139	-1.6	1220	5.6	874	4.0	+346	+1.6	16
	MAR.	21298	+742	10796	+748	50.7	20033	+699	11119	+401	+3.7	55.5	8914	+401	+4.7	1581	7.1	1096	4.9	+485	+2.2	16
	APR.	21568	+270	10994	+198	51.0	20273	+240	11554	+435	+3.9	57.0	8719	-195	-2.2	1338	6.0	1283	5.7	+55	+0.3	16
	MAY	21490	-78	11020	+26	51.3	20884	+611	11951	+397	+3.4	57.2	8933	+214	+2.5	1613	7.2	1638	7.3	-25	-0.1	16
	JUN.	21819	+329	11321	+301	51.9	21107	+223	12227	+276	+2.3	57.9	8880	-53	-.6	1807	8.3	1619	7.5	+188	+0.8	16
	JUL.	21772	-47	11331	+10	52.0	21068	-39	12219	-8	-.065	58.0	8849	-31	-.3	1682	7.7	1634	7.5	+48	+0.2	16
	AUG.	22120	+348	11312	-19	51.1	21310	+242	12286	+67	+.55	57.7	9024	+175	+2.0	1207	5.4	2128	9.5	-921	-4.1	18
	SEP.	19706	-2414	9922	-1390	50.4	19116	-2194	11018	-1268	-10.3	57.6	8098	-926	-10.3	405	1.9	2617	12.8	-2212	-10.7	18
	OCT.	17977	-1729	8847	-1075	49.2	17459	-1657	9900	-1118	-10.1	56.7	7559	-539	-6.7	135	0.7	1860	9.9	-1725	-9.2	18
	NOV.	17508	-469	8617	-230	49.2	16943	-516	9482	-418	-4.2	56.0	7461	-98	-1.3	542	3.1	1006	5.7	-464	-2.6	18
	DEC.	17614	+106	8563	-54	48.6	16844	-99	9330	-152	-1.6	55.4	7514	+53	+.7	814	4.6	700	4.0	+114	+0.6	18
1945	JAN.	18710	+1096	9084	+521	48.6	18121	+1277	10178	+848	+9.1	56.2	7943	+429	+5.7	1872	10.3	781	4.3	+1091	+6.0	18
	FEB.	18981	+271	9158	-74	48.2	18287	+166	10456	+278	+2.7	57.2	7831	-112	-1.4	967	5.1	702	3.7	+265	+1.4	18
	MAR.	19520	+539	9523	+365	48.8	18738	+451	10610	+154	+1.5	56.6	8128	+297	+3.8	1251	6.5	912	4.7	+339	+1.8	18
	APR.	19335	-185	9590	+67	49.6	18812	+74	10542	-68	-.64	56.0	8270	+142	+1.7	977	5.0	1158	6.0	-181	-1.0	18
	MAY	18717	-618	9283	-307	49.6	18247	-565	10045	-497	-4.7	55.1	8202	-68	-.8	835	4.4	1457	7.7	-622	-3.3	18
	JUN.	17003	-1714	8307	-976	48.9	16400	-1847	8801	-1244	-12.4	53.7	7599	-603	-7.4	284	1.6	2004	11.2	-1720	-9.6	18

EXHIBIT NO.23

SHIFT DISTRIBUTION

DOUGLAS-OKLAHOMA CITY

C-47

EXHIBIT NO. 24

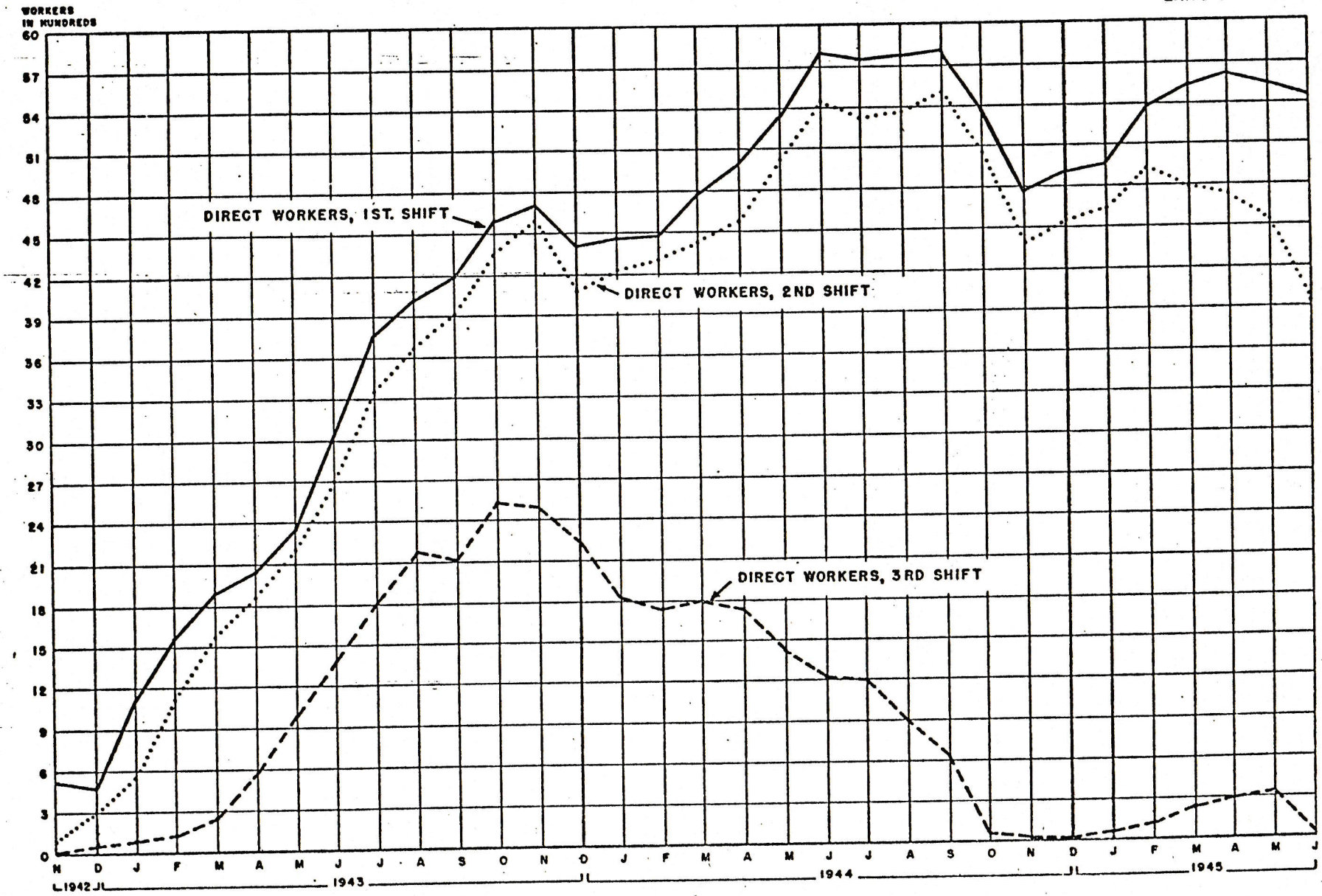


EXHIBIT NO. 24

MANAGEMENT

The Douglas Aircraft Company, Inc., of Santa Monica, California, acting upon the original Letter of Intent relative to the manufacture of C-47 airplanes at Oklahoma City, immediately formed a nucleus of managerial personnel for the new Oklahoma City plant. Such personnel were withdrawn from the Santa Monica and Long Beach plants, in a manner that would permit other persons to take over their duties without unduly retarding production of the parent plants.

The organizational plan as originally set up for the Oklahoma City Plant remained basically the same throughout the entire production period, although numerous managerial difficulties arose, especially during the first 12 months of operation.

Top management assigned to the Oklahoma City plant was very capable and instilled high morale and an over-all spirit of cooperation among their workers and foremen, which was far above the industry average.

Initiation and Growth of Organization

As production was originally expected to begin in the Oklahoma City Plant in September 1942, the group of personnel selected from the Douglas, California plants, for managerial positions at Oklahoma City, occupied temporary office space in Los Angeles as early as 15 May 1942, in order to duly plan operational procedures.

By July 1942 the plant manager, plant engineer, and personnel and purchasing groups had been transferred to Oklahoma City and temporarily located in a downtown office building. During August, September and October of 1942, all remaining managerial personnel, totalling 379 persons, were transferred to Oklahoma City.

Due to lack of completion of sufficient office space and because of advantages gained by being on the plant site, the entire managerial group was transferred to a completed garage building on the plant site during November 1942. All managerial personnel were moved into the administrative section of the new building in March 1943, at which time building construction was approximately 95% complete.

In sequence with increased production demands the number of managerial and supervisory personnel were increased, the major portion of these persons being promoted from the ranks. Due to the great percentage of new employees, many persons so promoted, had very little training and experience as is evidenced by the following tabulation of experience of lead men taken early in 1943.

6.6%	5 yrs. or more experience
3.9%	3 to 5 years experience
9.3%	1 to 3 years experience
5.5%	7 to 12 months experience
74.7%	Less than 7 months experience.

From the original nucleus of 379 persons transferred from California plants, managerial and supervisory personnel increased to an all-time high of 507 persons during the early part of 1944 (2.4% of total employees).

Basic Organization and Changes

The basic organization was comprised of 27 administrative units, the principal executive of each having been appointed from the key personnel transferred from California prior to assuming duties at Oklahoma City. During the early production period, the major portion of these 27 units, reported directly to the executive offices at Santa Monica and Long Beach. Most important of these responsibilities under headquarters control were financial, contract administration, industrial and public relations, engineering, tooling and material control. The organization chart, dated 1 June 1945, (Reference Exhibit No.25), reflects the organization as it existed from the beginning of operations until the end of the production period during this war emergency. Of the executives in charge of each of these units, only 2 were replaced during the entire production period for reasons conducive to more effective operation. There were, however, numerous changes among minor supervisors, as many of these positions were very difficult to fill, necessitating probational appointments and, in most cases, extensive training resulting in try-out methods, letting individuals advance, stand or fall, depending strictly upon their own merits.

Appraisal of Operations

Methods of managerial control used in the Oklahoma City organization were for each administrative or operating unit to maintain lines of strict accountability within its own sphere. The chief of each unit was directly charged with the full responsibility for his unit. Under this system effective contact was maintained with the executive office and exchange of ideas facilitated among executive and supervisory personnel.

In the early phase of the production period, functional relationship between the parent plants and the new Oklahoma City plant were not clearly defined and various problems arose, especially with respect to the relationship of tooling, controllers functions and engineering.

Of special interest is the development of the Time Standards Department, which during the early part of 1944 was developed to

a very efficient degree, enabling management to exercise close and effective control of over-all production departments.

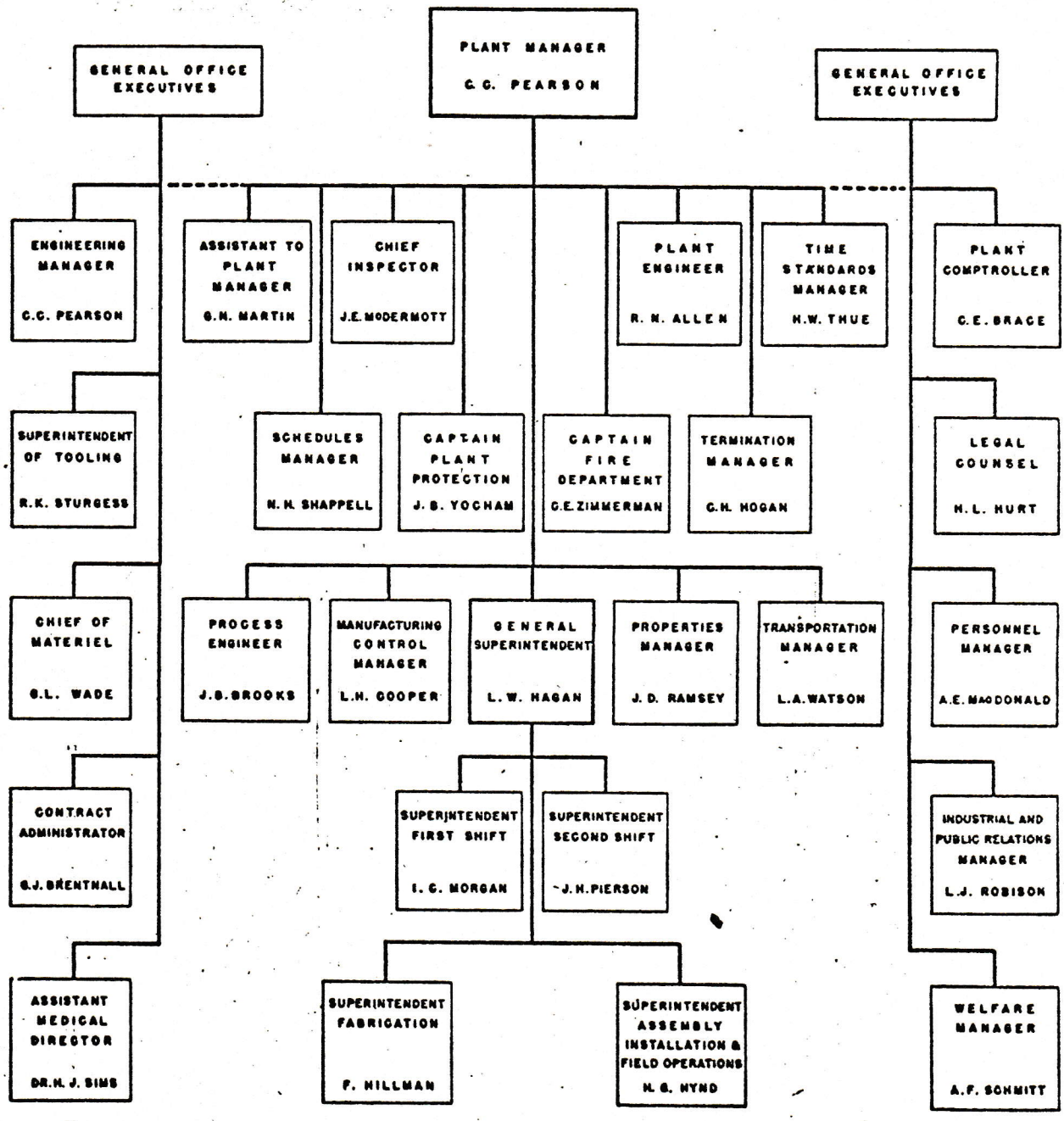
The plant manager, through his knowledge of aircraft manufacturing gained by many years experience with Douglas Aircraft, was able to develop among his subordinates a high morale and unanimity of purpose. With due consideration given to difficulties encountered which were beyond the control of the local organization, the over-all result was that Oklahoma City established an outstanding record in its production of the C-47 transport plane.

EXHIBIT NO 25

ORGANIZATION CHART – OKLAHOMA CITY PLANT

DOUGLAS AIRCRAFT COMPANY, INC.

JUNE 1 1945



APPENDIX

ON-SITE POUNDS ACCEPTED PER SQ. FT.

DOUGLAS-OKLAHOMA CITY

C-47

EXHIBIT NO.26

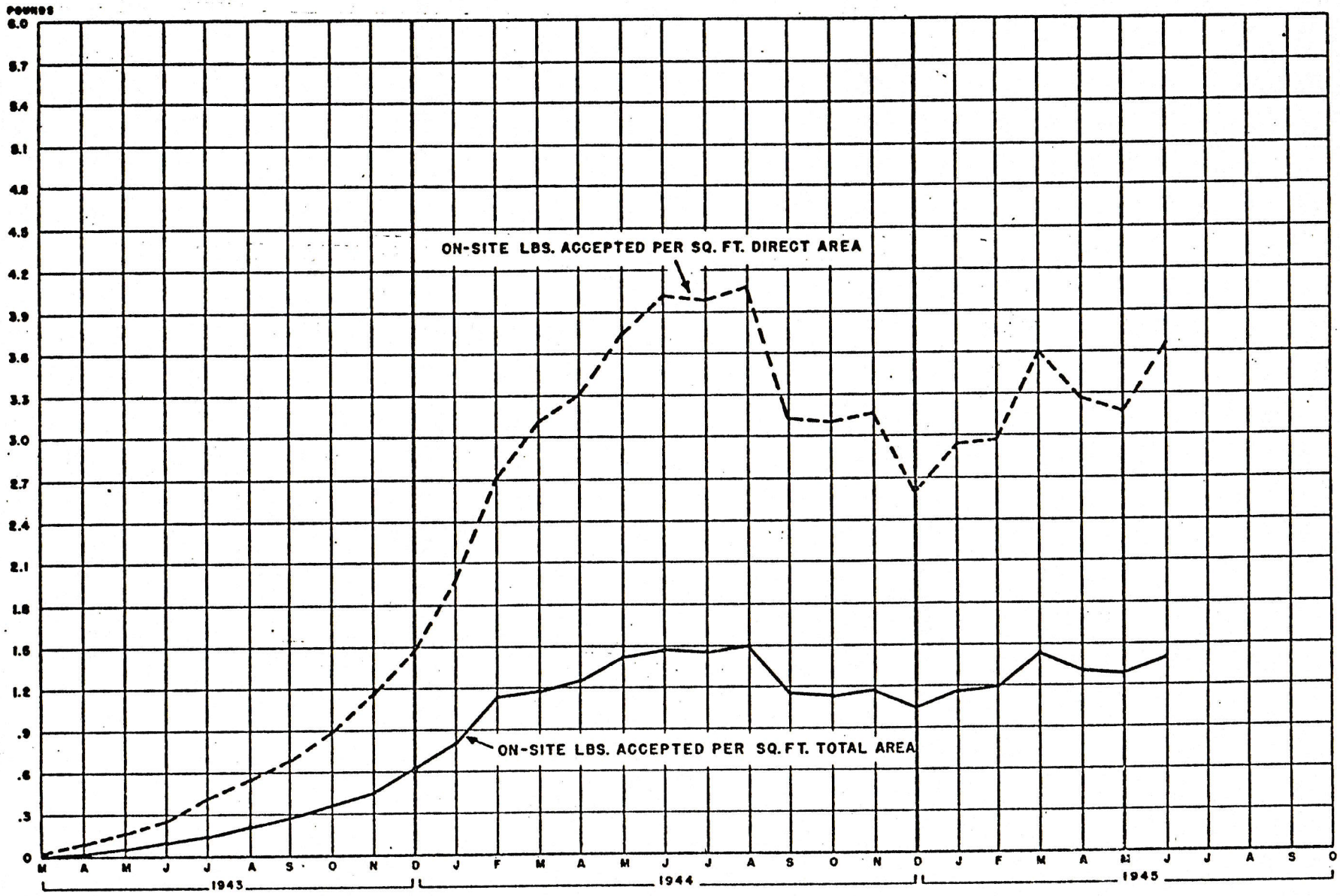


EXHIBIT NO. 26

ACCEPTANCES BY CONTRACT

DOUGLAS OKLAHOMA CITY C-47

EXHIBIT NO.27

MODEL	CONTRACT NO	QUANTITY	1943										TOTAL	1944											TOTAL	1945						TOTAL
			M	A	M	J	J	A	S	O	N	D	↓	J	F	M	A	M	J	J	A	S	O	N	D	↓	J	F	M	A	M	J	↓
C-47A	28405	1899	2	11	20	30	33	37	50	67	85	130	465	164	237	251	267	306	309							1534							
C-47A	40552	300											0						12	288						300							
C-47B	28405	1											0						1							1							
C-47B	40652	1682											0							24	320	311	312	300	255	1522	153	6				1	160
C-47B	2032	985											0													0	63	161	189	165	191	196	985
TG-47B	AC-40852	18											0									1	0	0	5	6	11	1					12
TC-47B	2032	116											0													0	3	24	27	35	26		116
C-117A	2929	131											0													0					1	3	4
C-47B	2929	1053											0													0							0
	TOTAL ACCEPTANCES		2	11	20	30	33	37	50	67	85	130	465	164	237	251	267	306	322	312	320	312	312	300	260	3363	230	192	216	200	218	200	1256
	CUMULATIVE ACCEPTANCES		2	13	33	63	96	133	183	250	335	465	-	629	866	1117	1384	1690	2012	2324	2644	2956	3268	3568	3828	-	4058	4250	4466	4666	4884	5084	-

EXHIBIT NO.27

MONTHLY ACCEPTANCES – RATES OF INCREASE

DOUGLAS OKLAHOMA CITY C-47

EXHIBIT NO.28

	1943										1944												1945					
	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
CUMULATIVE MONTHS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
ACTUAL ACCEPTANCES	2	11	20	30	33	37	50	67	85	130	164	237	251	267	306	322	312	320	312	312	300	260	230	192	216	200	218	200
CUMULATIVE ACCEPTANCES	2	13	33	63	96	133	183	250	335	465	629	866	1117	1384	1690	2012	2324	2644	2956	3268	3568	3828	4058	4250	4466	4666	4884	5084
RATE OF INCREASE (% CUM. TOTAL)	-	550	154	91	52	39	38	37	34	39	35	38	29	24	22	19	16	14	12	11	9	7	6	5	5	4	5	4
RATE OF INCREASE (% PREV. MO.)	-	550	182	150	110	112	135	134	127	153	126	145	106	108	115	105	97	103	98	100	96	87	88	83	113	93	109	92
																(PEAK)												
ACCEPTANCES FROM TREND CURVE	2	5	9	15	25	37	50	70	96	130	180	237	260	280	306	322												
NET INCREASE	+2	+3	+4	+6	+10	+12	+13	+20	+26	+34	+50	+57	+23	+20	+26	+16												
CUM. ACCEPTANCES	2	7	16	31	56	93	143	213	309	439	619	856	1116	1396	1702	2024												
RATE OF INCREASE (% CUM. TOTAL)	-	250	129	94	81	66	54	49	45	42	41	38	30	25	22	19												
RATE OF INCREASE (% PREV. MO.)	-	250	180	187	187	148	135	140	137	135	138	132	110	107	109	105												
NO. ACC. FROM TREND, % PEAK	.62	1.55	2.80	4.66	7.78	11.49	15.53	21.74	29.81	40.37	55.90	73.60	80.75	86.96	95.03	100.00												
CUM. MOS., % TOT. MOS. AT PEAK	6.25	12.50	18.75	25.00	31.25	37.50	43.75	50.00	56.25	62.50	68.75	75.00	81.25	87.50	93.75	100.00												

EXHIBIT NO.28

COMPLETIONS–ACCEPTANCES–DELIVERIES

DOUGLAS OKLAHOMA CITY C-47

EXHIBIT NO.29

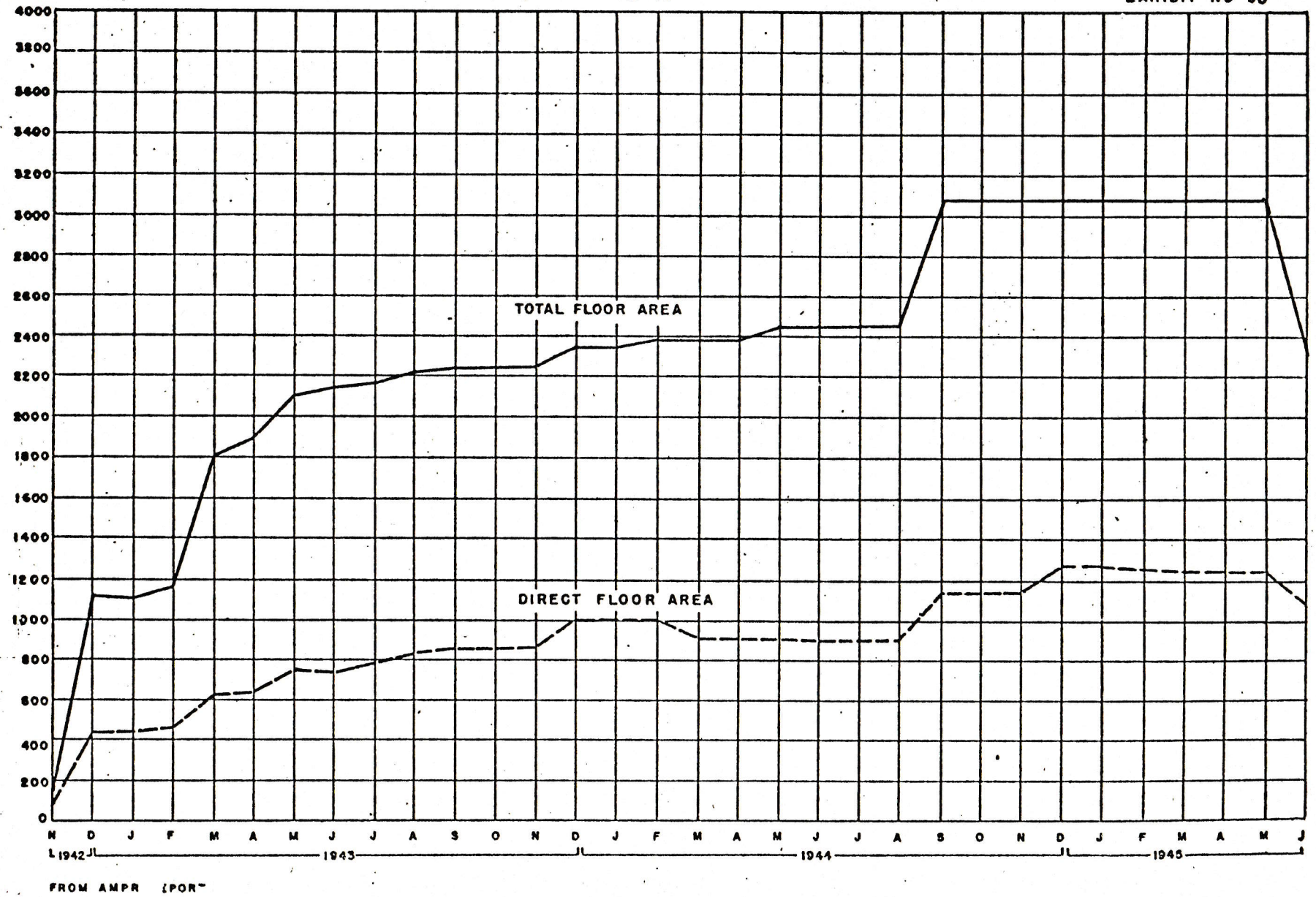
	1943										1944												1945					
	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
SHOP COMPLETIONS						37	67	72	133	135	170	209	240	266	286	303	324	337	321	320	295	255	242	198	208	192	207	197
S.C.B.U.A.						0	7	12	62	67	73	45	43	44	24	5	17	34	43	51	46	41	53	59	51	43	32	29
ACCEPTANCES	2	11	20	30	33	37	50	67	85	130	164	237	251	267	306	322	312	320	312	312	300	260	230	192	216	200	218	200
A.B.U.D.						15	15	2	13	38	24	1	2	0	0	0	1	38	20	24	38	69	33	70	9	13	13	29
DELIVERIES						38	50	80	74	105	178	260	250	269	306	322	311	283	330	308	286	229	266	155	277	196	218	184
EFFECTIVE SCHEDULES	2	11	20	30	43	53	58	60	85	110	164	180	218	267	306	322	312	320	312	312	300	260	230	192	216	200	218	211
ACCEPTANCES	2	11	20	30	33	37	50	67	85	130	164	237	251	267	306	322	312	320	312	312	300	260	230	192	216	200	218	200
+ OR –	0	0	0	0	-10	-16	-8	+7	-	+20	0	+57	+33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-11
CUM. EFFECTIVE SCHEDULE	2	13	33	63	106	159	217	277	362	472	636	816	1034	1301	1607	1929	2241	2561	2873	3185	3485	3745	3975	4167	4383	4583	4801	5012
CUM. ACCEPTANCES	2	13	33	63	96	133	183	250	335	465	629	866	1117	1384	1690	2012	2324	2644	2956	3268	3568	3828	4058	4250	4466	4666	4884	5084
+ OR –	0	0	0	0	-10	-26	-34	-27	-27	-7	-7	+50	+83	+83	+83	+83	+83	+83	+83	+83	+83	+83	+83	+83	+83	+83	+83	+72

EXHIBIT NO.29

FLOOR AREA

DOUGLAS-OKLAHOMA CITY
C-47

EXHIBIT NO 30



FROM AMPR [POR

EXHIBIT NO. 30

BUILD-UP OF DIRECT MAN-HOURS

EXHIBIT-NO.31

DOUGLAS OKLAHOMA CITY C-47

YEAR & MONTH		DIR. MAN-HRS. ACTUAL (000)	CUM. MAN-HOURS (000)	DIR. MAN-HRS. (FROM CURVE) (000)	NET CHANGE IN DIR.MH. (FROM CURVE) (000)
1942	NOV.	33	33	33	
	DEC.	193	226	193	+160
1943	JAN.	378	604	378	+185
	FEB.	538	1142	600	+222
	MAR.	819	1961	819	+219
	APR.	1028	2989	1028	+209
	MAY	1266	4256	1360	+332
	JUN.	1472	5727	1620	+260
	JUL.	1935	7662	1940	+320
	AUG.	2026	9688	2026	+86
	SEP.	2189	11877	2100	+74
	OCT.	2384	14261	2200	+100
	NOV.	2272	16533	2220	+20
	DEC.	2091	18624	2220	0
1944	JAN.	2022	20646	2240	+20
	FEB.	2184	22830	2260	+20
	MAR.	2474	25304	2280	+20
	APR.	2120	27424	2340	+60
	MAY	2600	30024	2600	+260
	JUN.	2584	32608	2584	-16
	JUL.	2467	35075	2467	-117
	AUG.	2588	37663	2300	-167
	SEP.	2322	39985	2175	-125
	OCT.	2089	42074	2089	-86
	NOV.	1897	43971	1897	-192
	DEC.	1638	45609	1638	-259
1945	JAN.	1624	47233	1500	-138
	FEB.	1360	48593	1360	-140
	MAR.	1425	50018	1300	-60
	APR.	1268	51286	1200	-100
	MAY	1340	52626	1150	-50
	JUN.	1269	53895	1100	-50

DIRECT MAN-HOURS – ACCEPTANCES AND TREND CURVE

DOUGLAS – OKLAHOMA CITY

C-47

EXHIBIT NO. 32

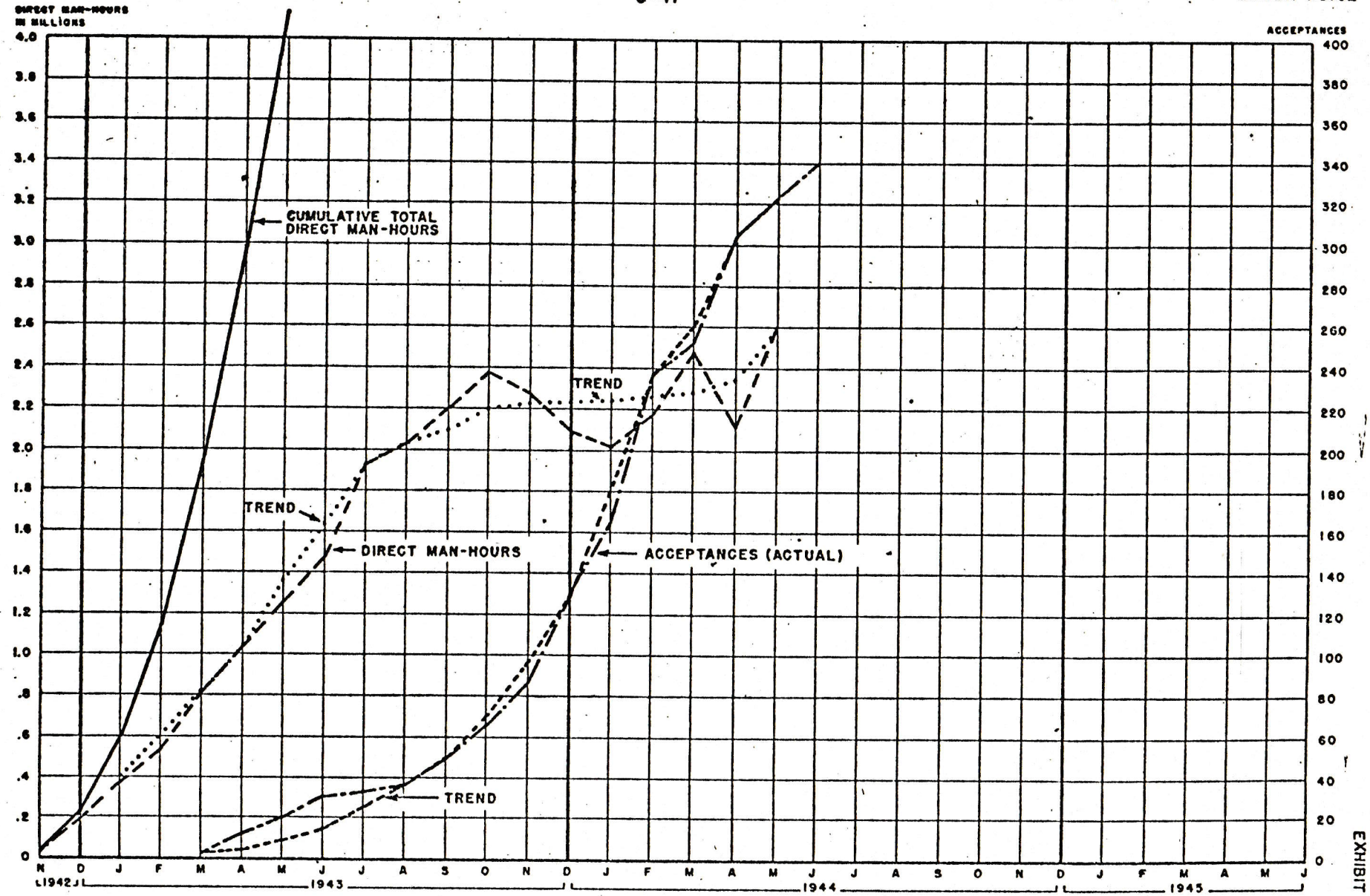


EXHIBIT NO. 32

DIRECT LABOR PROGRESS CURVE

DOUGLAS - OKLAHOMA CITY
C-47

EXHIBIT NO. 33

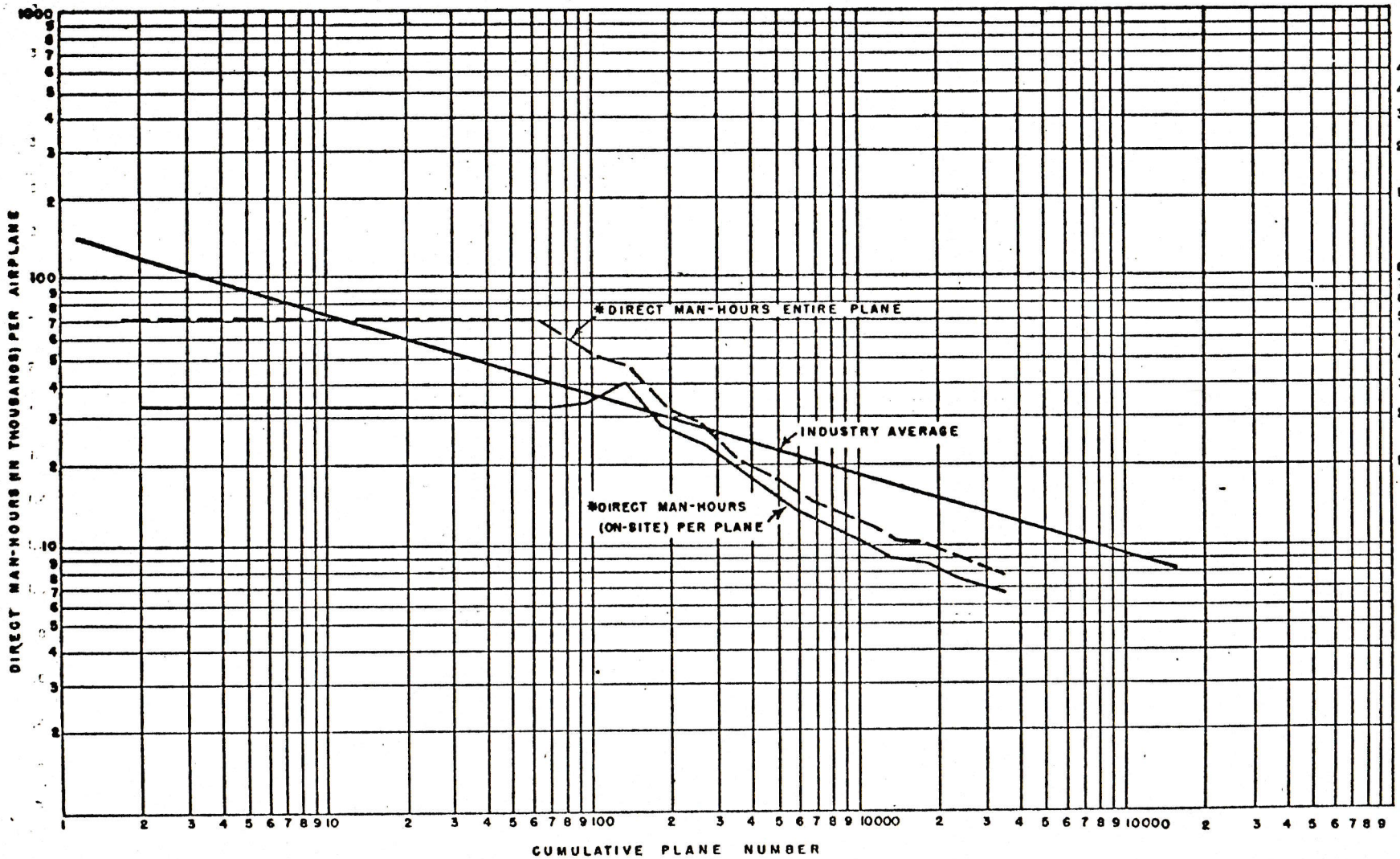


EXHIBIT NO. 33

* FROM AMPR

AREA UTILIZATION

DOUGLAS - OKLAHOMA CITY

C-47

EXHIBIT NO. 34

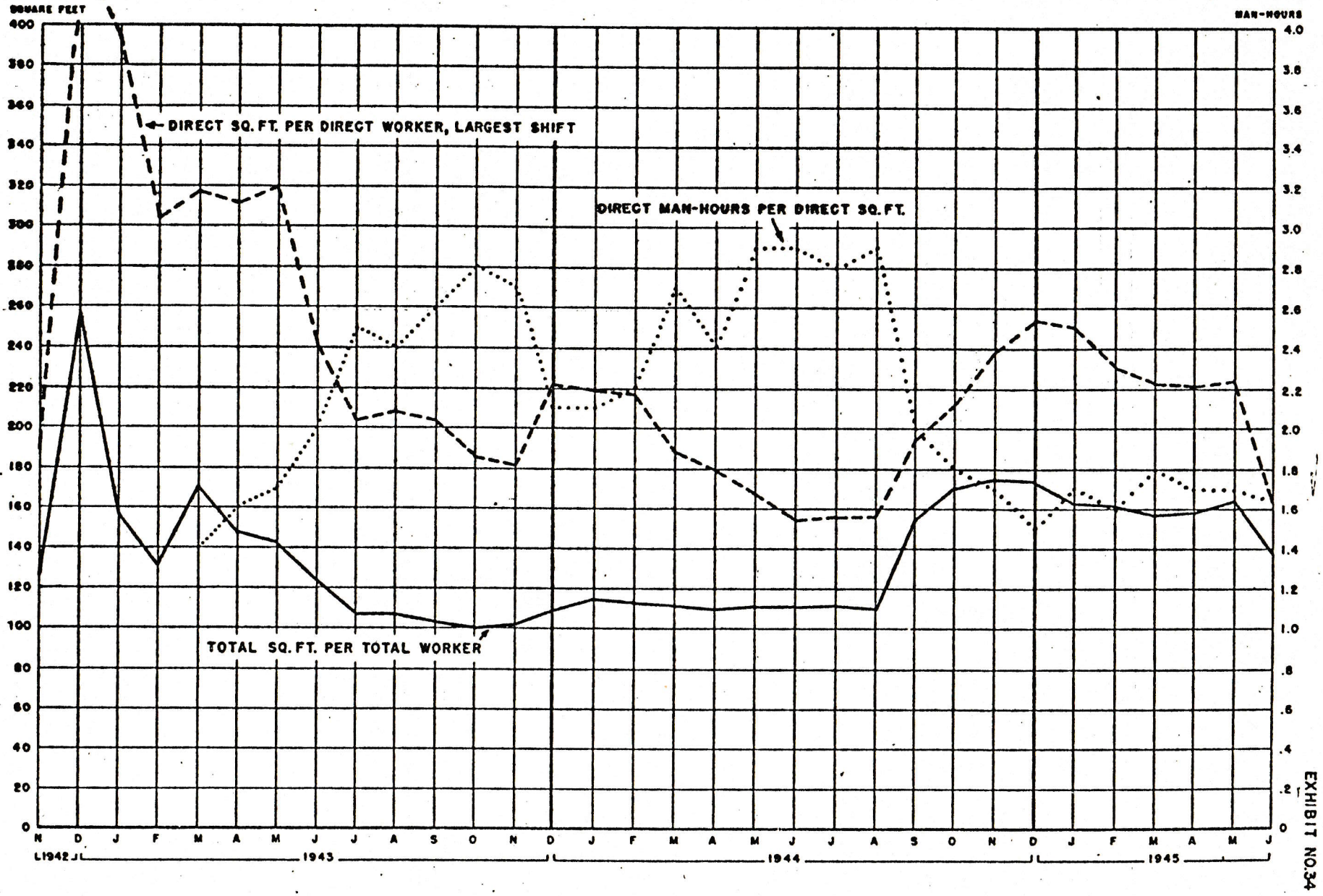


EXHIBIT NO. 34

AREA UTILIZATION AND OUTPUT

DOUGLAS OKLAHOMA CITY C-47

EXHIBIT NO.35

YEAR & MONTH	TOTAL FLOOR AREA	DIRECT FLOOR AREA				DIR. YARD AREA	DIRECT WORKERS			WORK WEEK		ABS-CENCE RATE	NO. OF ACCEPT.	TOTAL LBS. ACC.			ON-SITE LBS. ACC. C.U. S.P.	FL'R. AREA USED FOR PROD. C.U. S.P.		DIR. M-HRS. PER DIR. SQ. FT.	TOTAL SQ. FT. PER TOTAL WRK'R	DIR. SQ. FT. PER DIR. WORKER LAR SHIFT	ON-SITE LBS. ACC. PER SQ. FT.		% O.P.	COMP. O.P.
		TOTAL	DIR. % TOTAL	AERO	EXP. NON-AERO		FIRST SHIFT	2 ND % 1 ST	3 RD % 1 ST	ACT-UAL	SCHED			C.U.	S.P.	C.U. S.P.		TOTAL	DIR.				TOTAL AREA	DIR. AREA		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
1942 APR.	2	NR	NR	NR	0	0																				
MAY	2	NR	NR	NR	0	0																				
JUN.	3	NR	NR	NR	0	0																				
JUL.	3	NR	NR	NR	0	0																				
AUG.	NR	NR	NR	NR	0	0																				
SEP.	NR	NR	NR	NR	0	0																				
OCT.	NR	NR	NR	NR	0	0																				
NOV.	172	91	52.9	NR	3	0	536	15.9	4.9	44.8	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	126	170				
DEC.	1108	448	40.5	NR	0	0	981	61.3	13.4	43.4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	257	914				
1943 JAN.	1113	440	39.5	440	0	0	1114	50.4	7.3	44.9	47.6	2.4	0	0	0	0	0	0	0	0	157	395	0	0		
FEB.	1168	473	41.2	473	0	0	1356	69.9	7.7	44.8	47.6	4.1	0	0	0	0	0	0	0	0	133	304	0	0		
MAR.	1810	603	33.3	603	0	0	1696	83.6	13.6	46.7	47.4	4.2	2	24	0	24	11	1810	603	1.4	171	318	.01	.02	53	47
APR.	1887	640	33.9	640	0	0	2054	91.1	28.2	47.5	46.8	3.8	11	133	1	134	63	1887	640	1.6	148	312	.03	.10	53	47
MAY	2104	752	35.8	752	0	0	2350	93.6	42.0	48.6	46.4	4.3	20	242	10	252	118	2104	752	1.7	143	320	.06	.16	53	47
JUN.	2131	735	34.5	735	0	0	3037	89.0	46.1	47.0	46.2	4.6	30	383	40	403	189	2131	735	2.0	125	242	.09	.26	53	47
JUL.	2161	768	35.5	768	0	0	3758	89.8	48.3	47.0	46.1	5.8	33	399	72	471	311	2161	768	2.5	107	204	.14	.40	34	66
AUG.	2214	838	37.8	838	0	0	4024	91.2	53.8	45.6	46.0	5.2	37	448	112	560	470	2214	838	2.4	107	208	.21	.56	15	85
SEP.	2274	857	37.7	857	0	0	4205	93.1	50.7	46.7	46.1	4.4	50	605	97	702	590	2274	857	2.6	104	204	.26	.69	16	84
OCT.	2274	857	37.7	857	0	0	4599	95.3	55.1	45.8	46.5	5.4	67	811	105	916	769	2274	857	2.8	100	186	.34	.90	16	84
NOV.	2274	857	37.7	857	0	0	4711	97.6	53.0	45.6	46.7	5.0	85	1028	165	1193	1002	2274	857	2.7	101	182	.44	1.17	16	84
DEC.	2332	975	41.8	975	0	0	4409	94.5	50.9	43.7	46.8	6.6	130	1573	142	1715	1441	2332	975	2.1	109	221	.62	1.48	16	84
1944 JAN.	2332	975	41.8	975	0	0	4457	94.8	41.5	45.3	46.4	5.0	164	1984	318	2302	1934	2332	975	2.1	116	219	.83	1.98	16	84
FEB.	2332	975	41.8	975	0	0	4473	96.4	39.4	50.4	52.6	3.7	237	2868	287	3155	2650	2332	975	2.2	113	218	1.14	2.72	16	84
MAR	2380	902	37.9	902	0	0	4782	92.7	37.6	48.7	52.6	6.0	251	3037	304	3341	2806	2380	902	2.7	112	189	1.18	3.11	16	84
APR.	2380	902	37.9	902	0	0	4990	91.8	34.8	48.9	52.7	8.0	287	3231	323	3554	2985	2380	902	2.4	110	181	1.25	3.31	16	84
MAY	2380	902	37.9	902	0	0	5337	94.2	26.8	49.9	53.0	7.6	306	3703	296	3999	3358	2370	898	2.9	111	169	1.42	3.74	16	84
JUN.	2431	897	36.9	897	0	0	5799	93.9	21.1	50.2	53.2	7.2	322	3896	390	4286	3600	2429	896	2.9	111	155	1.48	4.02	16	84
JUL.	2431	897	36.9	897	0	0	5742	92.9	21.0	47.0	47.1	5.6	312	3775	491	4266	3583	2429	896	2.8	112	156	1.48	4.00	16	84
AUG.	2431	897	36.9	897	0	0	5762	92.7	15.5	46.0	47.3	6.1	320	3872	581	4453	3651	2431	897	2.9	110	156	1.50	4.07	18	82
SEP.	3077	1136	36.9	1136	0	0	5812	94.7	11.3	45.1	47.5	6.1	312	3775	529	4304	3529	3077	1136	2.0	158	195	1.15	3.11	18	82
OCT.	3077	1136	36.9	1136	0	0	5395	93.4	0.69	46.2	48.0	4.6	312	3775	529	4304	3529	3068	1133	1.8	171	211	1.15	3.11	18	82
NOV.	3077	1136	36.9	1136	0	0	4745	92.5	0.67	46.2	48.0	4.5	300	3630	617	4247	3483	2979	1100	1.7	176	239	1.17	3.17	18	82
DEC.	3077	1249	40.6	1249	0	0	4915	92.4	0.63	45.7	48.0	4.3	260	3146	378	3524	2890	2726	1107	1.5	175	254	1.06	2.61	18	82
1945 JAN.	3077	1249	40.6	1249	0	0	4875	93.1	0.96	47.3	48.0	4.3	230	2852	513	3355	2759	2323	943	1.7	164	251	1.19	2.93	18	82
FEB.	3077	1249	40.6	1249	0	0	5393	91.3	2.0	47.5	47.9	5.2	192	2381	666	3047	2499	2089	848	1.6	162	232	1.20	2.97	18	82
MAR.	3079	1239	40.3	1239	0	0	5532	86.4	4.3	47.4	50.0	5.3	216	2679	723	3402	2790	1921	773	1.8	158	224	1.45	3.61	18	82
APR.	3079	1239	40.3	1239	0	0	5599	84.8	5.3	46.8	50.1	6.1	200	2440	512	2952	2421	1841	741	1.7	159	221	1.32	3.27	18	82
MAY	3079	1239	40.3	1239	0	0	5543	82.2	6.4	46.1	49.8	5.7	218	2659	346	3005	2464	1921	773	1.7	165	224	1.28	3.19	18	82
JUN.	2340	896	38.3	896	0	0	5465	72.0	0.59	-	48.0	5.5	200	2440	268	2708	2221	1562	606	2.1	138	164	1.40	3.66	18	82

EXHIBIT NO.35

TOTAL EMPLOYMENT – NET CHANGE

DOUGLAS – OKLAHOMA CITY

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EXHIBIT NO. 36

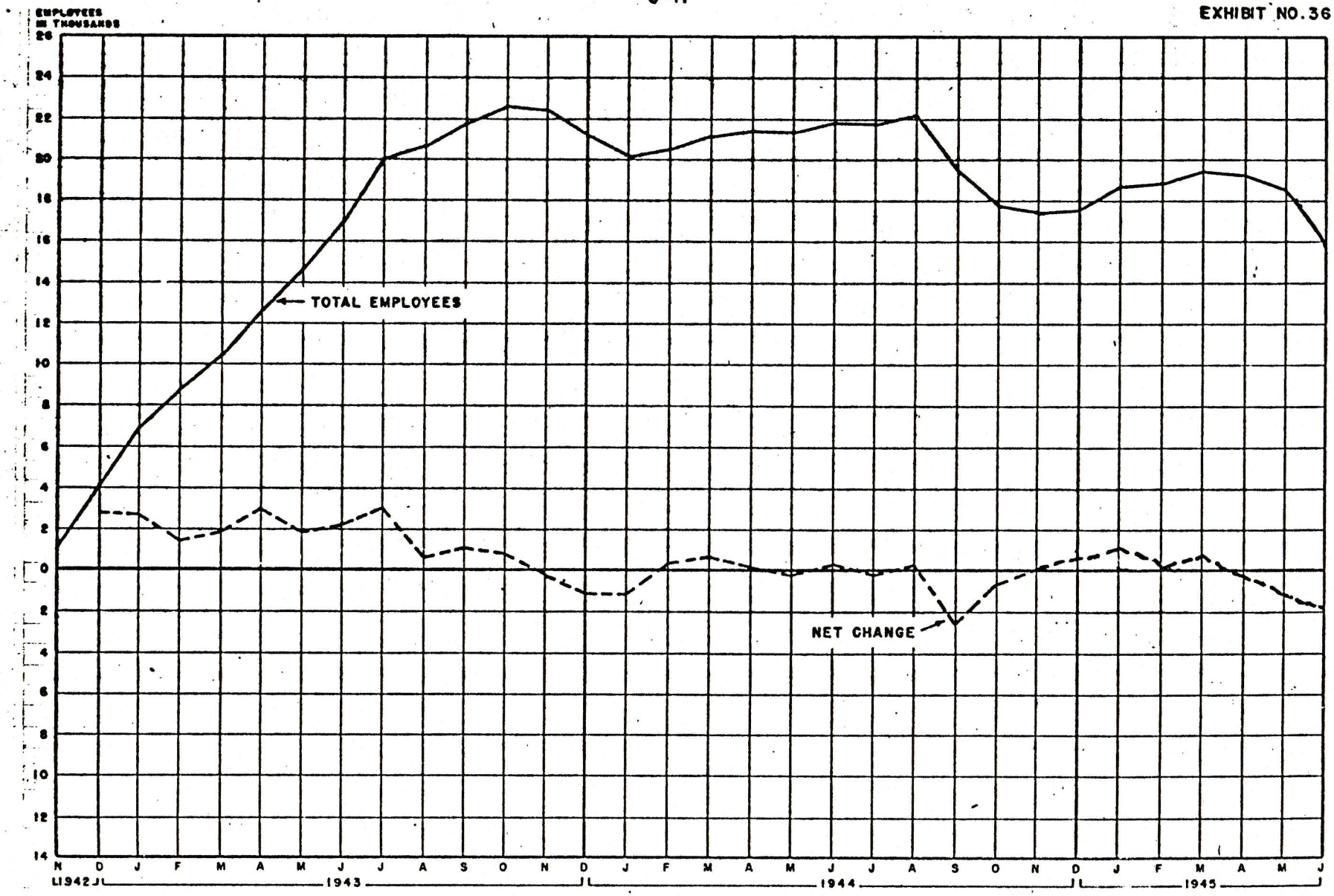

EXHIBIT NO. 36