TWA MAINTENANCE HANGAR
South side, Tinicum Island Road
Philadelphia International Airport
Philadelphia ~~vicinity~~
Philadelphia County
Pennsylvania

HAER No. PA-561

HAER
PA
51-PHILA,
713-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Northeast Region
Philadelphia Support Office
U.S. Custom House
200 Chestnut Street
Philadelphia, Pennsylvania 19106

HAER
PA
51-PHILA,
713-

HISTORIC AMERICAN ENGINEERING RECORD

TWA MAINTENANCE HANGAR

HAER No. PA-561

Location: South side, Tinicum Island Road. Philadelphia International Airport, Philadelphia ~~vicinity~~, Philadelphia County, Pennsylvania.

UTM:18. 478615.4413580
Quadrangles: Woodbury, N.J.-Pa. and Bridgeport, N.J.-Pa. 1:24,000

Date of Construction: 1955-1956

Architects: The Ballinger Company, Philadelphia, Pennsylvania

Engineers: Ammann and Whitney, New York, New York

Steel Fabricators: Lehigh Structural Steel Company, Allentown, Pennsylvania

Present Owner: City of Philadelphia
Division of Aviation
Philadelphia International Airport
Terminal E
Philadelphia, Pennsylvania 19153

Present Use: Vacant. Last use, maintenance hangar for US Airways.

Significance: The TWA Maintenance Hangar is an early and unusual example of the use of a cable supported roof structure to provide the clear floor space needed for an airplane hangar. It was determined eligible for the National Register of Historic Places by the Pennsylvania Historical & Museum Commission for its exceptional importance in engineering.

Project Information: The TWA Maintenance Hangar is located on a portion of the site of the proposed International Terminal One at Philadelphia International Airport. Construction of this terminal will necessitate demolition of the hangar. Preparation of Historic American Engineering Record documentation is intended to mitigate the adverse effect of this demolition.

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John Milner Associates, Inc.
535 North Church Street
West Chester, Pennsylvania 19380
1999

DESCRIPTION

The TWA Maintenance Hanger is located at Philadelphia International Airport. Its site is southwest of the passenger terminal complex on the south side of Tinicum Island Road. South of the hangar are tarmacs and taxiways of the airport. The TWA Cargo Building is located immediately west of the hangar, and warehouses of Cargo City are located further west. A gatehouse and security gates are located east of the hangar.

(Note: The TWA Maintenance Hangar is actually located in Lester vicinity, Delaware County, Pennsylvania. However, "Philadelphia vicinity, Philadelphia County" is given here as the "official location," since the major part of the airport is located within the city limits of Philadelphia. "Lester vicinity, Delaware County" then becomes the "reference location.")

This hangar was used for servicing and maintaining large commercial aircraft. The rectangular building measures 270 feet wide by 173 feet deep and is two stories in height with a mezzanine. It rests on a concrete slab foundation. Its walls, faced with brick, are of reinforced concrete construction.

The northwest facade is divided into bays by concrete bents that serve as anchoring points for cables that support the roof cantilever. Both the first and second stories of the north facade are fenestrated with ribbons of metal-framed, industrial windows. Several first story bays are marked by steel, overhead loading doors, while other bays contain single-light steel entry doors below transom windows. The main entrance to the building is situated off-center on the north facade wall. It is marked by a steel-framed, flat canopy anchored to the flanking concrete bents. The main entrance consists of paired, steel-framed, glass doors set within a plate glass surround.

The southeast facade of the building is marked by the wide hangar opening. This opening is enclosed by two sets of three, motor-operated, corrugated, overlapping, steel hangar door leafs, each 45 feet long. These doors are topped with 10 foot wide inclined canopies, hinged at both top and bottom to allow for deflection of the cantilevered steel roof ribs. The top edge of the canopy is supported on trolleys running in continuous guides mounted at the end of the cantilever. Wheels mounted to the lower edges of the doors roll on guide rails embedded in the concrete of the hangar floor. Because the connection of the trolley to the canopy is hinged, the canopy is a flexible link connecting the door to the roof structure. To provide a clear opening for the entire width of the hangar, the door guides are cantilevered 45 feet past the ends of the roof. The upper portion of each leaf is fenestrated with a grid of 16, 10-light industrial windows that provide illumination for the hangar floor when the doors are closed.

The northeast side wall of the hangar has a projecting, full-width rectangular, first story bay. This bay is marked by corrugated steel, rolling doors spaced across its first story. The first story wall is also pierced by a ribbon of aluminum frame windows and several single-light, steel entry doors. The second story level is fenestrated with translucent, asbestos, insulated panels set with a framework constructed of aluminum battens. The southwest wall contains a single, corrugated steel, overhead door. A rectangular, full-height bay projects from its north end.

The roof consists of two sections. The north section, a shallow, shed lean-to, is supported by the bearing walls of the north portion of the building. The shallow arched south section is cantilevered and is supported by the steel roof framework and by the cable system that is visible above the roof. The roof edge is marked by an aluminum valance. A neon sign that reads "FLY TWA" is anchored to the center of the lean-to roof by steel-framed scaffolding. A second sign reading simply "TWA" is anchored to the center of the south edge of the cantilevered roof, while a third neon "TWA" sign is mounted to the upper east end wall of the lean-to.

The bulk of the interior of the building, all that portion beneath the cantilevered roof, is an open, concrete-floored. maintenance and repair area. The column free hangar bay measures 135 feet deep by 270 feet long. In addition, the east end of the lean-to section is open and serves as an extension of the repair area. The remainder of the lean-to is separated from the maintenance area by a concrete wall. This wall is pierced by steel doors, and two steel-framed staircases provide access to second story doors from the repair floor. The first story of the lean-to is divided into a series of full-depth garage, shop, equipment, and storage areas and partial width offices. The second floor and mezzanine consist largely of offices and assembly rooms to one side of a single loaded corridor. Most of these spaces have walls constructed of plaster board, dropped acoustic tile ceilings, and vinyl floor tiles. A single story, free standing shop area with a US Air logo painted on its exterior wall was constructed at the west end of the hangar floor in recent years. The total ground floor area is 53,000 square feet. The mezzanine measures 2,600 square feet, and the second floor, 12,200 square feet.

The ceiling of the hangar hay is equipped with direct-indirect fluorescent light fixtures. These fixtures throw part of their light upward, illuminating the entire ceiling and improving the uniformity of lighting intensity. The steel trusswork of the ceiling is visible in the interior of the hangar.

The cable-suspended roof has a deck constructed of precast concrete channel slabs. These slabs rest on steel purlins that span 30 feet between 36-inch wide-flange beams or ribs. The ribs are supported at one end by the lean-to and at the other end by the cables. The 40-foot-wide lean-to serves two purposes. First, it serves as anchorage for the cables, and secondly it provides space for functions related to the operation of the hangar.

The cables used to support the cantilever consist of two 2 9/16-inch steel bridge strands which pass over 32-foot-high steel masts. The ten cables are anchored with bolts in the heavy concrete bent framing of the lean-to. Each pair of strands carries a load of 329 tons.

In an article in *Civil Engineering*, Donald Pierce, an associate with Ammann and Whitney, described the structural engineering characteristics of the building. The axial load of the ribs is quite high as a result of the horizontal component of cable tension. This tension is counterbalanced by the compression in the bottom chord of the cantilever truss. The bending movements in the ribs vary markedly over the rib because of its shape. The maximum moment occurs at the connection of the rib to the bent and amounts to 797 kip-ft but drops off very rapidly away from this point. Neither the axial load nor the bending movements are beyond the capacity of standard 36WF sections, reinforced locally with relatively light cover plates.

Pierce discussed the engineering of the ribs:

> The shape of the rib reduces the shear in the member because of the vertical component, but this is of incidental importance, since the shears are light, and well within the capacity of the section. Lateral buckling of the rib is effectively restrained by the purlins and lateral bracing, while by curving the rib slightly and controlling the point of application of the axial load, the bending moments can be kept within the capacity of the section...
>
> As designed, the rib consists of three straight chords, with splices at the break points. One field splice is necessary because of shipping restrictions. It was felt that this solution represented the best possible resolution of the somewhat conflicting structural, esthetic, economic, and dimensional requirements (Pierce 1956:45-46).

The design also addressed the potential for overturning due to deadload and snow load implicit in the design of a long cantilever. The problem was dealt with by the use of relatively heavy framing in the lean-to, and the use of tension piles under the rear legs of the bents (Pierce 1956:46).

HISTORY

Philadelphia International Airport

The first Philadelphia commercial airport, known as Central Airport, was located across the Delaware River in Pennsauken, immediately east of Camden, New Jersey. This site had limited possibilities for expansion due to the planned Cooper River Park to its south and was also subject to fog and smoke (Ford, Bacon, and Davis 1928:27). The site of Central Airport is now the Airport Business Park.

A portion of the present Philadelphia International Airport was selected as the site of an airport in 1922. The original site, comprising 125 acres, is situated in the northeast corner of the present airport. In 1925, the City of Philadelphia agreed to operate the airfield as a training facility for aviators of the Pennsylvania National Guard. The following year, the city entered into a contract with Ludington Exhibition Company, the predecessor of Eastern Airlines, to operate the facility as the Municipal Aviation Landing Field (Thompson 1975:5).

In 1930, the adjacent Hog Island was purchased using $3 million in federal funds to allow for airport expansion. Because of the Depression, this expansion was delayed. In 1936, expansion plans were drawn up by the Airport Coordinating Board, and construction began in 1937. The airport, designated Philadelphia Municipal Airport, was formally opened in June 1940. Four airlines, American, Eastern, TWA, and United, that had served the city through Central Airport, terminated operations there and moved to Philadelphia Municipal Airport. The airport served approximately 40,000 passengers during its first year of operation (Thompson 1975:5-6). The airport's growth was stifled by its temporary closure on December 23, 1943 because of wartime operations at the nearby Hog Island ammunition depot (Anonymous 1945).

In the years after World War II, Philadelphia operated two airports, the Municipal Airport and the North Philadelphia Airport. Initially, the two Philadelphia airports were small, inadequate for the needs of a city of its size. Laurence P. Sharples, chairman of the aviation subcommittee of the Chamber of Commerce, estimated that between $5 to $10 million dollars would be necessary to provide adequate aviation facilities. He said that facilities at the airports were "about right for Boise, Idaho" and that the fields lacked space even to store a spare engine (Anonymous 1945).

In 1945, Municipal Airport was renamed Philadelphia International Airport when American Overseas Airlines inaugurated transatlantic passenger service at the facility. In 1950, construction was begun on a new $15 million terminal building. This terminal was dedicated on December 15, 1953. In 1955, a new 45,000 square foot building was constructed for the exclusive use of air cargo. During that year, a total of 540,230 passengers used the airport for scheduled air service. On August 2, 1959, TWA inaugurated the first jet service at Philadelphia with a non-stop Boeing 707 flight to Los Angeles (Thompson 1975:6). To accommodate increasing numbers of passengers, a $3.5 million, 847-foot extension of the passenger terminal was dedicated in December 1962 (Forsythe 1962).

Documents in the Philadelphia Division of Aviation archival files at the Philadelphia City Archives indicate that serious discussion of Trans World Airlines (TWA) hangar requirements at Philadelphia International Airport had begun by 1953 (Buckley to Phillips, March 17, 1953). The existing hangars at the airport, completed in 1950, were a group of four, attached, glass-fronted, gable-roofed buildings with brick-clad fire walls (Philadelphia City Archives photographic files). With the increased size of aircraft, larger hangars were also needed. The TWA Maintenance Hangar was constructed in 1956 to accommodate these larger aircraft. It was owned by the City of Philadelphia and leased to the airline.

The hangar was designed by The Ballinger Company, Architects and Engineers (architect of record: Valentine B. Lee, Jr.). Structural engineers for the building were Ammann and Whitney of New York. Steel fabricator for the building was the Lehigh Structural Steel Company of Allentown, while the general contractor was Baton Construction Corporation of Philadelphia. The hangar doors were fabricated by Byrne Doors, Inc.

The Ballinger Company, which touts itself as the oldest continually operating architectural firm in the City of Philadelphia, traces its history back to 1878 when Walter Harvey Geissinger established himself in practice in the city. In 1885, Geissinger entered into a partnership with Edward M. Hales. Four years later, Walter Francis Ballinger entered the firm of Geissinger and Hales. In 1895, Ballinger replaced Geissinger as a principal in the firm, and it became known as Hales and Ballinger. In 1901, Edward M. Hales retired, and in 1902, the firm was renamed Ballinger & Perrot. After Ballinger bought out Emile G. Perrot in 1920, the firm became known as Ballinger Company. The *Biographical Directory of Philadelphia Architects* describes the firm's practice as "concentrating primarily on industrial and commercial structures" (Tatman and Moss 1985:298, 30-31). The firm has designed many buildings throughout the United States and Canada but is best known for its innovative industrial facilities (JMA 1989:14). Ballinger remains among the largest architectural firms in the Philadelphia region with the greatest portions of its work devoted to educational, medical, and research facilities (AIA 1997:57).

The engineering firm, Ammann and Whitney, was co-founded in 1946 by Othmar H. Ammann, a preeminent twentieth century bridge engineer, and Charles S. Whitney, a pioneer in developing ultimate strength methods in concrete design. Among the firm's best known airport projects is the engineering design for Eero Saarinen's Dulles Airport (ENR 1992:18).

Hangar Technology

Originally used primarily for storage of aircraft, airplane hangars are now used primarily for maintenance and repair of aircraft. The TWA Maintenance Hangar was most recently leased by U.S. Airways for this purpose. In addition to an open area in which to work on aircraft, hangars are typically equipped with areas for materials, storage, shops, offices, and employee conveniences. The nucleus of a hangar is an enclosed space having a clear span and roof height sufficient to accommodate the largest aircraft which it is expected to house.

By 1940, hangars were being constructed of both structural steel and concrete. Structural steel hangars used large steel roof trusses to provide the clear span needed. Typical examples were the two hangars then in use at the Allegheny County Airport in Pittsburgh. One of the hangars was steel-framed, while the other was steel-framed with masonry side walls. Both had a shallow gabled roof supported by a steel truss, and the larger of the two had a hangar space 150 feet deep by 40 feet wide (Wood 1940:131, 134). These hangars were of sufficient size to accommodate the small propeller-driven airplanes then in use.

In a 1940 book on airport design and construction, the authors advocated the use of concrete hangars to accommodate modern aircraft, a technology which drew upon concrete bridge construction. Techniques of concrete rigid frame and concrete arch construction could be used to construct large clear span buildings. Other buildings, including auditoriums, armories, and hangars, used concrete "shell dome" technology (Glidden, Law, and Cowles 1940:221).

Existing pre-1945 hangars in Philadelphia include two at the former Naval Base Philadelphia. Building 537, a steel-framed and concrete, flat-roofed building, has a roof supported by a steel truss. Building 653, a 1943 seaplane hangar, uses concrete arches to provide clear span (McVarish et al. 1994).

As American passenger aircraft increased in size, hangar roof technology evolved to accommodate the changing needs. A sample of the evolution of hangar design in the 1950s was presented in an article in *Engineering News-Record* on hangars at the New York International Airport, presently Kennedy International Airport.

Hangars 3, 4 and 5, which, in actuality, formed a continuous, three-barrel, arched-roofed building, had roofs supported by three-hinged steel arches. The three-hinged arch had long been the standard means of spanning a large space without intervening columns. The technology was developed in train sheds designed by Philadelphia's Wilson Brothers and others. The three-hinged arched roofs of this hangar provided a clear lateral span of 300 feet (Anonymous 1956c:42).

Hangar 6 was completed in July 1954. In place of the three-hinged arch, the primary structural component was six 140-foot steel bowstring trusses, placed side by side. In place of intermediate walls, these trusses were supported by five king trusses, running from the front to the back of the hangar. Hangar 7, completed in November 1954, relied on a two-story shop and office center section. This section was framed in steel to provide support for the exposed cantilever system from which 133-foot trusses extended. Hangar 8, completed in July 1955, and Hangar 9, completed in December 1955, used a similar structural principle to Hangar 7. However, unnlike Hangar 7, the cantilever design was modified to eliminate exposing the trusswork (Anonymous 1956c:42-43).

Cable Roof Structures

The TWA Maintenance Hangar is notable for the cable support of its cantilever roof. As such, it was one of the early examples of this structural technology in the United States. The Roman Colosseum, built in 70 A.D., represents the earliest known use of cables for roof support. Rope cables anchored to masts extended in a radial fashion across the open stadium and supported a large sunshade that could be drawn from either side to cover the arena (Bethlehem 1968:3).

Cable-supported technology was used throughout much of recorded history for suspension bridges and in recent centuries for support of temporary buildings such as tents. It was only in the late nineteenth century that the technology was again employed for the support of roofs of buildings. In 1896, a cable-suspended roof was used in an exhibition pavilion built at Nijny-Novgorod, Russia and designed by engineer V.G. Shuchov (Otto 1969:16). In 1933, the first prominent American building incorporating a cable-supported roof was constructed, the Travel and Transport Building at the 1933 Chicago World's Fair (Guise 1989:715).

These modern examples were both temporary buildings at exhibitions, venues in which experimental building technology and design has often been used. The first permanent United States buildings that used cable roof structures were erected in the 1950s.

There is no generally agreed-upon terminology for cable roof structures. Richard M. Gensert, a structural engineer, defined cable roof structures as "any roof structure which employs the steel cable as a load-bearing, structural element." Gensert divides these roof structures into two basic types, cable-suspended and cable-supported. Defining these terms, Gensert wrote:

> A "cable-suspended" roof uses cables to carry the roof load directly. There are two variations in this principle: (1) cases where the roof deck is carried directly on the cable, and (2) cases where additional loads, such as ceiling frames are suspended directly from and below the cable.
>
> In a "cable-supported" system, the roof loads are generally carried by rigid structural members. Here the cables serve as added support for the rigid structure (Bethlehem 1968:4).

This terminology is used in the following discussion.

The first major building in the United States that incorporated a cable roof structure was the North Carolina State Fair Arena in Raleigh, completed in 1953. The cable roof structure was designed by Matthew Nowicki, an architecture faculty member at North Carolina State University. This building is described in *Cable Roof Structures*:

> Parabolic in plan, elevation, and section, it is a 300-ft.-diameter cable-suspended structure using a single set of cables.... The...arena has post-tensioned concrete slab foundations at each end. From these foundations, two concrete arch ribs flare upwards and outwards to form the outer rim of the structure. These ribs, supported by steel columns up to 85 ft. high at the center, carry the roof cables which span 300 ft. in each direction over a column-free area (Bethlehem 1968:27).

Because of the need for large, column-free spaces, many later arenas and assembly buildings used cable roof structures. United States examples include the David S. Ingalls Ice Hockey Rink, Yale University (1958); the Utica (New York) City Auditorium (1959); the Nicholson Pavilion of Central Washington State College (1959); the Blyth Arena, Squaw Valley, California (1959); Villita Auditorium, San Antonio, Texas (1960); Seattle Center Coliseum (1961); the Travelers Insurance Companies Pavilion, New York World's Fair (1963); the State of New York Pavilion, New York World's Fair (1963); the Oklahoma State Fair Arena (1964); the Arizona Veteran's Association Coliseum, Phoenix (1965); the Tulsa County (Oklahoma) Exposition Center (1966); the Oakland-Alameda County Coliseum (1966); Madison Square Garden, New York (1967); the Forum, Los Angeles (1967) (Bethlehem 1968:95-96); and the Pontiac (Michigan) Silverdome (1975) (Guise 1989:717). Examples constructed in other countries include the Olympic Gymnastic Pavilion, Seoul, Korea; the Munich Olympic Stadium (Guise 1989:716); and the Australian Pavilion at the International Exhibition, Osaka, Japan (Krishna 1978:6). Most of these buildings employed cable-suspended roofs.

The other major American building type that began to employ cable roof structures during the 1950s was the airport hangar. As with arenas and assembly buildings, large column-free spaces were critical for this building use. The earliest example of a U.S. hangar that employed cable roof technology is the TWA Airframe Overhaul Building, built at the Mid-Continent International Airport near Kansas City, Missouri in 1955-1956. This building, which had a cable-supported roof, was described in an *Engineering News-Record* article:

> Omission of columns is made possible by cable suspension of two, thin-shell, corrugated concrete roofs on opposite sides of a central shop and office section, which also serves as anchorage for the cables. The roofs, each 818 by 150 ft (plus a 10-ft door overhang), cover enough area to house nine Constellation-type and four Martin 4-0-4 type aircraft simultaneously (Anonymous 1956a:44).

Shortly after construction of the Kansas City hangar, two additional cable-supported hangars were built: the TWA Maintenance Hangar in Philadelphia and the Pan American (Pan Am) Hangar at Idlewild (present Kennedy) International Airport in New York City. Both hangars were cited in engineering literature of the time as exemplifying newly developed roof support technology. The general technology employed in both of these hangars was later described in *Cable Roof Systems*:

> By definition, a cantilever is a projecting beam or member unsupported at one end. This type of technology is used extensively in erecting huge hangars to house and serve today's king-size jet planes. However, an important qualification is that there be no interior columns or posts. To achieve this column-free space under long spans, the cable-

> supported roof principle is sometimes employed to achieve an unusual method of cantilevering.
>
> One end of the roof member is fastened to a bearing wall, while the other end is held up by prestretched, galvanized bridge strands. If a double-cantilever construction is used, dead load is relatively unimportant because one cantilever balances the other. On the other hand, dead load can cause design problems with a single cantilever, because of the overturning movement. The single-cantilever Philadelphia hangar is designed to effectively control this force by anchoring the cables in heavy concrete bents at the rear of the structure (Bethlehem 1968:40).

Similar to the TWA Kansas City hangar, the Pan Am hangar featured roofs cantilevered to either side of a central block. An article in *Civil Engineering* described this building:

> The hangar has a three-story center section 100 ft wide and 630 ft long, and a folded-plate, cable-supported, post-tensioned roof slab extending 130 ft from each side of the center section. Clearance under the roof at the hinge is 35 feet, rising to 53 ft at the outer end (Prokop 1957:60).

The Philadelphia hangar differed from these two other early cable-suspended roof hangars in several fundamental ways. First, as mentioned, it employed a one-sided cantilever, instead of the paired cantilever used in TWA Airframe Overhaul Building and in the Pan Am hangar. Second, the cantilever employed steel-frame technology rather than the folded plate concrete technology of the other two hangars. Third, the roof loads were not transmitted to the sliding doors. Several articles appended to this document describe the design of this hangar in detail. A summary of its design is contained in a January 1956 issue of *Engineering News-Record*:

> This hangar's 130 foot roof is supported on steel ribs...hung on steel cables. It is only a one-sided cantilever with the anchorage for the cables provided by a concrete bent lean-to running the length of the bangar. The cables are carried over steel saddles on a 28-ft-high post to the tip of the suspended span.....
>
> Ten pairs of 2 9/16 in. cables, spaced 30 ft c-c, support the 270-ft long roof....These cables will be attached to 4-in-dia high-strength steel studs, 29 ft long at the door end of the hangar and 11 ft long at the anchorage.
>
> A semi-rigid connection joins the steel girder to the concrete bent. To reduce rotation at this connection and also to provide better sheer strength, the designers use high-strength bolts, tightened to provide compression between the end of the girder and the bent.
>
> Precast concrete channel slabs form the roof deck for the hangar. They were selected because the designers found...the wind uplift condition on the roof was sufficient to overcome dead load. Danger of this occurring placed a 14-psf lower limit on the weight of roof decking chosen (Anonymous 1956b).

Several other hangars constructed in the late 1950s also used cable-supported roofs. These include the TWA New York Maintenance Hangar with its paired 150-foot-deep roof cantilevers to either side of a central block (Anonymous 1958:47), completed in 1957 (Bethlehem 1968:95); and the U.S. Navy Hangar at Hanscom Air Force Base, Bedford, Massachusetts, completed in 1959). The Navy hangar used a double cantilever design that measured 260 feet wide and 186 feet long (Bethlehem 1968:40-41).

Other non-hangar airport buildings have also incorporated cable roof structures. The earliest major example was the Pan American Terminal at Idlewild (now Kennedy) International Airport, New York, completed in 1959. This terminal featured a 4-acre, elliptical cable suspended roof that overhung to protect passengers from the elements (Bethlehem 1968:32-33).

By far the best-known example of an airport building with a cable roof structure is the Dulles International Airport Terminal, designed by noted architect Eero Saarinen and completed in 1963. The massive concrete piers of the building supported a swooping cable-hung roof, and the outer walls of the terminal were largely glass (Anonymous 1960:57).

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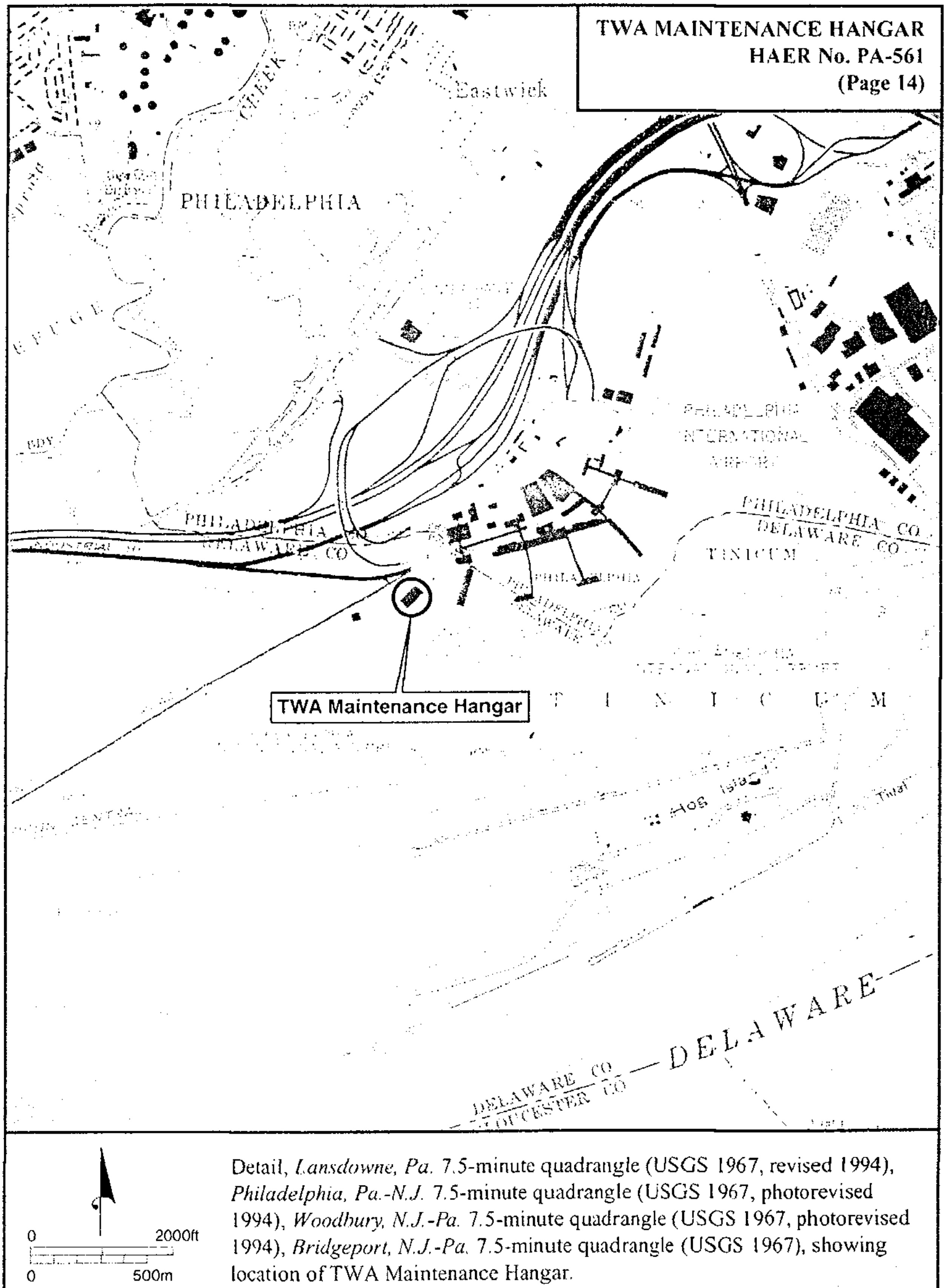
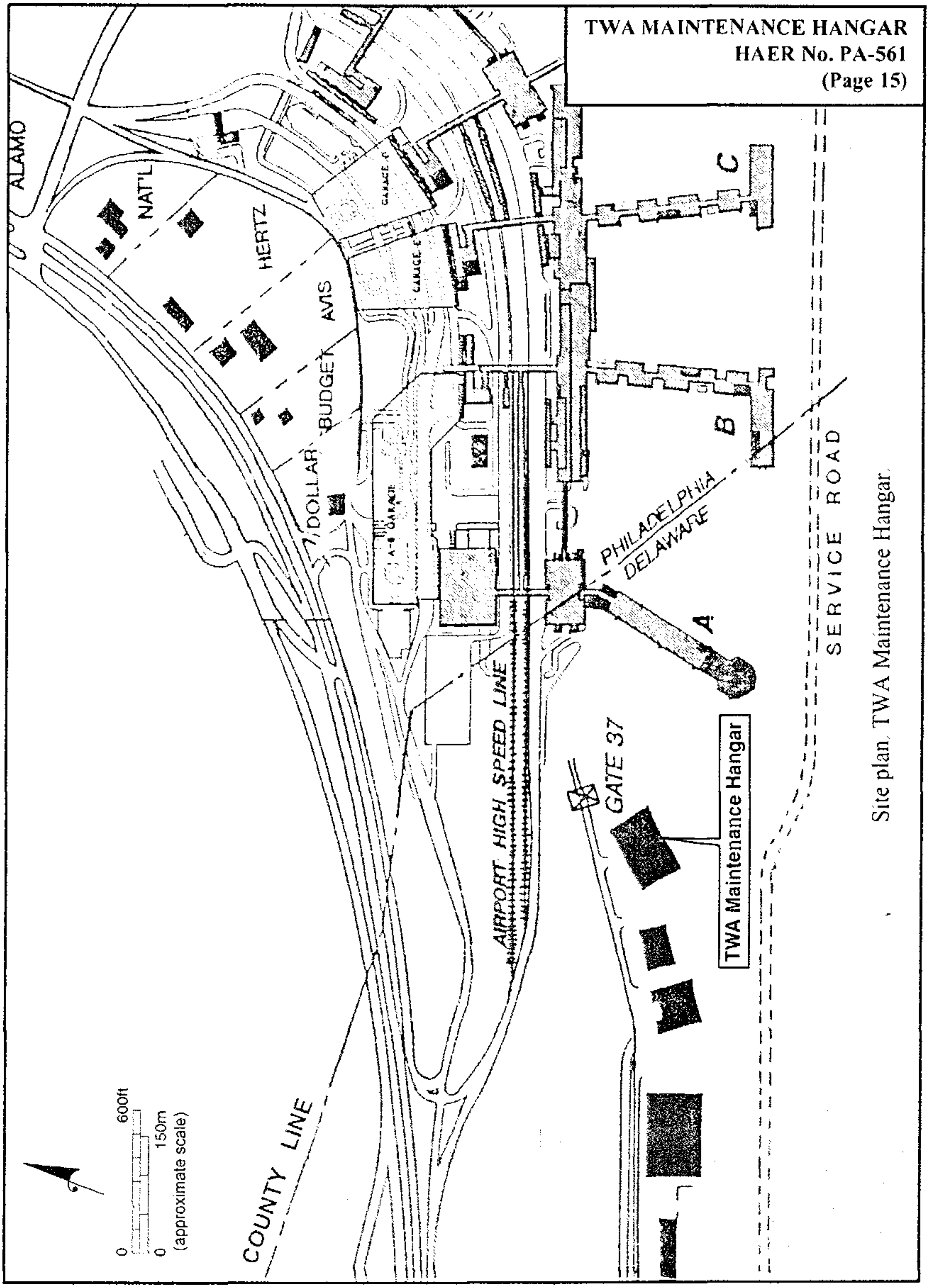


Detail, *Lansdowne, Pa.* 7.5-minute quadrangle (USGS 1967, revised 1994), *Philadelphia, Pa.-N.J.* 7.5-minute quadrangle (USGS 1967, photorevised 1994), *Woodbury, N.J.-Pa.* 7.5-minute quadrangle (USGS 1967, photorevised 1994), *Bridgeport, N.J.-Pa.* 7.5-minute quadrangle (USGS 1967), showing location of TWA Maintenance Hangar.



Site plan. TWA Maintenance Hangar.