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# THE SLATE ALL METAL AIRSHIP

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ABSTRACT: This paper will cover the development of the Slate all metal airship "City of Glendale" built and completed in 1930. A brief discussion of the airship facilities accompanied by slides will be covered. Pertinent data which led to other engineering accomplishments for aviation will be covered and shown. The paper will deal with the SMD-100 concept, along with a brief commentary on the costs and problems involved in such an airship design and the application of the hoisting and elevator facilities to airship development.

In 1928, in the city of Glendale, California, the Slate family, headed by Captain Benton Slate funded, designed, constructed and inflated the airship "City of Glendale." It was one of the four all metal airships built in the Lighter Than Air era. Unlike the ZMC-2 metalclad, the Slate was financed by a family group and considerable attention to cost was required with limited availability of outside sources.

The Slate design incorporated a gore panel structure which was formed on the world's largest stretch and form press and in the process corrugated for additional strength. The gores were placed along the hull longitudinally, while the hull was rotated with slings and counterweights to maintain the work area at a specified platform height.

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On completion, the hull was inflated with natural gas and floated to a second hangar facility where mating of the gondola was carried out. In this facility the hull was purged of the natural gas and inflated with hydrogen. Metal was German manufactured duraluminum in sheet form and imported to the United States. The second facility was also to be used for the installation of the powerplants and related modification work.

As with many aircraft, the Slate airship was taken out of the hangar for purposes of promotion and publicity, at which time it was to be turned around and brought back into the hangar to complete the installation of powerplants and flight controls. The person assigned to the control car to maintain the pressure controls was talked into leaving it for a few moments to have his picture taken. While this was happening, hull pressure expanded due to the hot California sunlight and caused the rupturing of a seam.

The hull gores were joined with a crimping process similar to that used on conventional food cans today. Internal ring structure of very light weight was riveted to the gores. So despite the sudden heavy pressure surge and the opening of a seam, damage was confined to a very small area and the airship was returned to the hangar with adequate time to spare for repairs. This alone was testimony to the ability of metal airships to sustain damage without catastrophic results. Had the same accident happened in flight, there would have been sufficient time to land and unload passengers.

The Slate design offered novel and significant changes in airship thinking, many of which have been adopted today by airship proponents. Passengers, fuel, crew and cargo were taken aloft by an elevator or hoisted aboard. The corrugation gave the hull unprecedented longitudinal strength.

The powerplant, which consisted of a high speed rotor, operated in such a manner as to cavitate air in front of the airship and pull it forward into what amounted to a vacuum. It also acted to redistribute the boundary layer and this permitted use of smaller control surfaces. As a result of tests the powerplant initially reached an effectiveness of 68.2 percent. Later refinements are reported to have increased this figure to almost 80 percent.

The Slate program required that they not only design and innovate, but become manufacturers of hydrogen gas, engineer the world's largest stretch and form press, and develop new ideas on the handling of cargo and passengers. Our film clips and slides will show these aspects.

In 1958, Claude C. Slate decided to follow in the family interest in airships and produced the Slate All Metal Dirigible SMD-100. This design has been copied in the USSR and was reported extensively in the 1960's by the Soviet press. The description and slides on the SMD-100 which follow are based on the design and engineering of a 7 million cubic foot airship and missions to which it is applicable.

The original design would have involved costs including the building of facilities, of 9 million dollars. With inflation and the way costs have gone up, the same design is estimated to cost now between 14 and 15 million dollars which includes the facilities.

The Slate airship like the ZMC-2 was an accomplished fact. Unlike the ZMC-2 which was designed from the start as an experimental prototype for the Navy, the Slate was for commercial application. In 1930 the depression was in full sway and funds planned for the development by the Slate family dried up. Within an 18-month period all work was abandoned on the airship and demands for the removal of the facility at Grand Central Airport were made, resulting in the scrapping of the uncompleted airship.

With the technology that exists today, the Slate airships could be manufactured and operating for unit costs of approximately 6 million dollars after a series of three to four were developed and facilities constructed.

A metal airship was recognized as the only answer to the many peril of the airships of the 20's and 30's. The Slate family contributed to our knowledge of airships and designs. More than any other organization they willingly gambled their own funds on development and would have succeeded except for the financial crash that shook not only the United States, but the world.

## SLIDES PRESENTED AT WORKSHOP

Slide #1
The Slate Aircraft Company was formed in the middle 20's. After an unsuccessful attempt to lease the blimp hangar at Ross Field in Arcadia, California, property was leased in the city of Glendale. angars were erected to produce the Slate All Metal Passenger Carrying Airship. The initial financing was by private capital and it wasn't until construction was well underway that stock was available to the general public. These ships were to be used strictly for carrying passengers and cargo.

Slide #2
The small hangar was for the construction of the hull and the larger hangar was for the final assembly of the cabin and powerplant.

Slide #3
The all metal monococque ship was 212 feet long, 58½ feet in diameter, with a total displacement of 330,000 cubic feet. Initially, it was to be powered by a 500 horsepower steam turbine. Total weight of the ship was under 14,000 pounds, and payload was approximately 8,000 lbs.

Slide #4
Airborne ship shown during one of the many tests for checking the powerplant, ballast, and elevator systems.

Slide #5
The first longitudinal sheet in place. The ship was made up of continuous longitudinal sheets and circular rings. The rings were produced on a yoder type roll. At the time the ship was started, 18-inch wide coiled aluminum in 200 foot lengths was the largest size available. It required splicing at the nose and tail sections. All work was performed on the horizontal centerline of the ship.

Slide #6
Hull approximately 75% complete. Note end of stretch and form press.

### Slide #7

Hull approximately 90% complete. All riveting was performed with hand operated rivet sets.

### Slide #8

Front end of hull showing work platform and splice of longitudinal sheet.

### Slide #9

The hull work crew putting the last sheet in place. 158 formed sheets made up the hull. The last sheet fit perfectly.

### Slide #10

Internal view of the hull. Note the simplicity of construction.

### Slide #11

Cabin under construction and ballonet undergoing inflation tests.

### Slide #12

Hull moving from small hangar to larger hangar for cabin attachment. Natural gas was used to initially purge the ship. At this point natural gas was used as a means of buoyancy.

### Slide #13

Hull suspended in a large hangar for cabin installation.

### Slide #14

In 1953 a larger ship of approximately 900,000 cubic foot displacement was proposed to the Navy. Complete design and structural analysis was furnished to the Navy.

### Slide #15

Performance data on the ship.

### Slide #16

Cabin arrangement, with live-on provisions for crew and submarine surveillance equipment.

### Slide #17

In 1960, lighter than air, as a means of moving missiles and related equipment was investigated by the government. The design of the 8,600,000 cubic foot ship with a 100 ton payload and a 2,400 mile range was started.

### Slide #18

The primary task was for moving the new Saturn booster and other outsized cargo.

### Slide #19

Performance data on the ship.

### Slide #20

Payload and operational data.

### Slide #21

The cargo bay was sized to carry the first stage of the Saturn booster.

Slide #22
The ship would have the capability of moving three Minuteman missiles.

Slide #23
Further studies brought about the SMD-100 and primary effort was directed to the Air Force and NASA.

Slide #24
The ship was configured to accomodate practically any size cargo. Two hoist bays were provided in place of the large cabin. The flight deck and crew quarters were in the lower fin.

Slide #25
Live-on accomodations for forty men were provided.

Slide #26
Specifications of the ship.

Slide #27
Performance of the ship.

Slide #28
Ten hoists in each bay are capable of picking up 300,000 pounds. Maximum height of pickup is 250 feet. The hoists are mounted on rails in each hoist bay and move fore and aft to handle cargo up to 160 feet in length. Auxiliary power is provided on the tips of the horizontal stabilizers. The powerplants swivel 360 degrees making it possible to turn the ship in twice its length.

Slide #29
Carrying the first stage of the Saturn booster.

Slide #30
Hoisting three Minuteman missiles.

Slide #31
Moving bridges and out-sized cargo.

Slide #32
Moving housing and emergency hospital.

Slide #33
Installation and servicing of remote radar installations.

Slide #34
Salvaging of aircraft.

Slide #35
Container loading or unloading without the use of conventional dock cranes. The ship would handle ten 40-foot sea-land containers, with each container weighing up to 30,000 pounds.

Slide #36
Container handling from ship to shore for remote areas without harbor facilities.

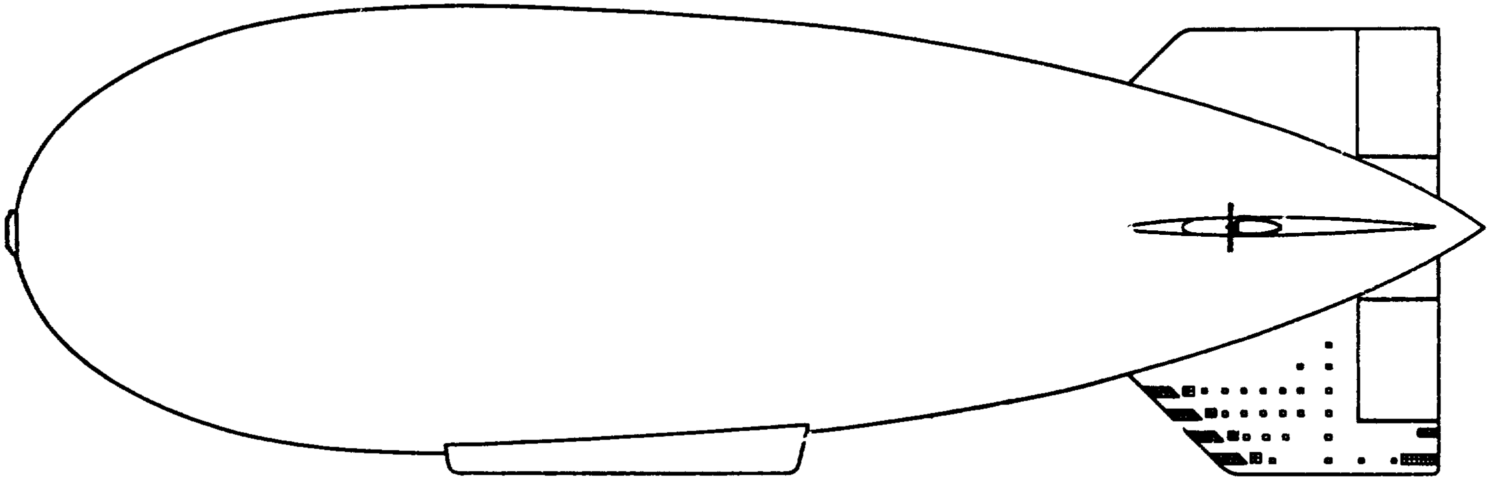
Slide #37
Moving, erecting, and servicing of oil well equipment.

Slide #38
Servicing of off-shore oil drilling platforms.

Slide #39
Transporting pipe line with prefabricated lengths up to 160 feet.

Slide #40
Transporting and servicing of remote housing and construction equipment.

Slide #41
Maintenance and servicing of remote mining operations.



# SLATE ALL-METAL DIRIGIBLE

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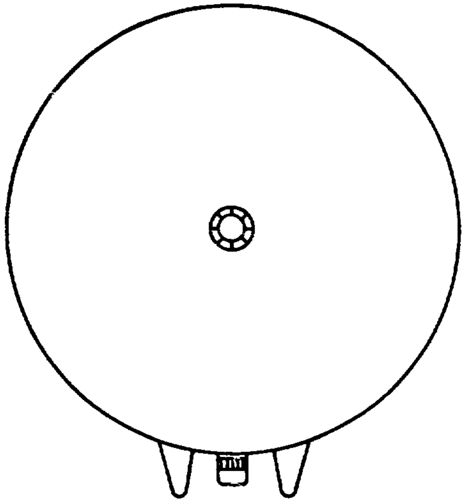
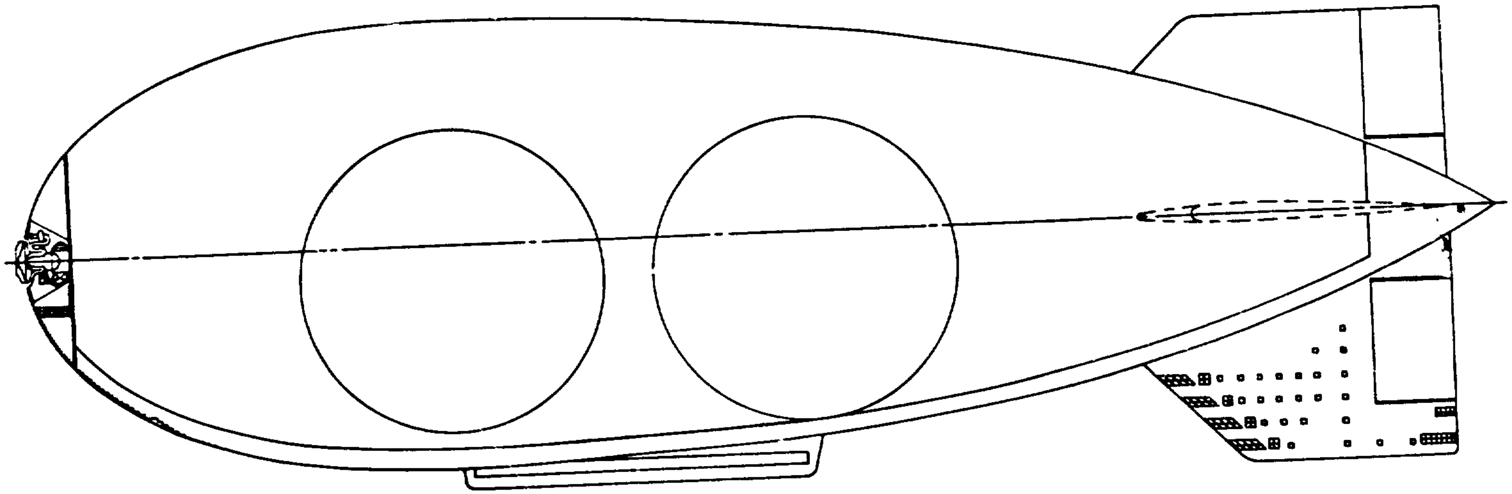
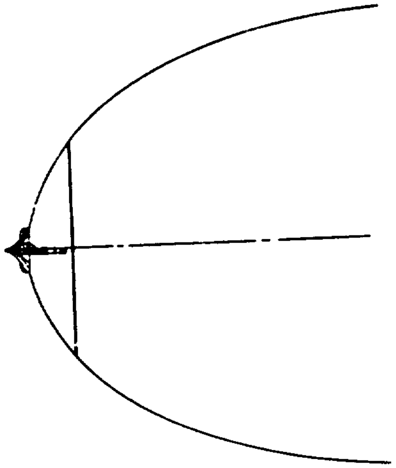
|---|---|
| Normal Take Off Helium Capacity | 7,804,133 Cu. Ft. |
| Gross Lift At Normal Take Off | 491,652 LB. |
| Weight Empty | 206,494 LB. |
| Useful Load | 285,158 LB. |
| Crew 25 Men | 5,250 LB. |
| Fuel and Oil | 73,420 LB. |
| Ballast | 9,005 LB. |
| Cargo Static Take Off | 197,483 LB. |
| Cargo Dynamic Take Off | 244,518 LB. |
| Range With 73,420 LB. of Fuel | 2,400 MI. |
| Maximum Fuel or Ballast Capacity | 340,000 LB. |
| Maximum Speed At 4672 S.H.P. | 100 M.P.H. |
| Cruising Speed at 3836 S.H.P. | 80 M.P.H. |
| Auxiliary Power Plants. 2 @ 250 H.P. each | 500 H.P. |
| Service Ceiling | 7500 FT. |







# SLATE ALL-METAL DIRIGIBLE

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|---|---|
| Length of Hull | 570 FT. |
| Diameter of Hull | 177 FT. |
| Maximum Height Over Hull and Cabin | 186 FT. |
| Fineness Ratio | 3.22 |
| Displacement of Hull | 8,671,258 CU. FT. |
| Total Ballonet Displacement | 1,734,251 CU. FT. |
| Ratio Ballonet Volume to Hull Volume | 20% |
| Thickness of Aluminum Alloy Skin | .014 |
| Width of Cabin | 8 Ft. |
| Capacity of Cabin | 44 Men |
| Number of Air Valves | 2 |
| Number of Gas Valves | 4 |
| Main Power Plant; Allison Model 510-H2 | 5000 H.P. |
| Maximum Area Covered by Cargo Hoist | 33.5 FT. x 120 FT. |
| Passenger Elevator Capacity | 12 Men |