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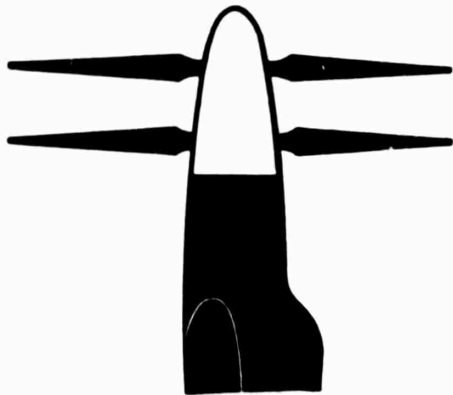
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SUMMARY REPORT
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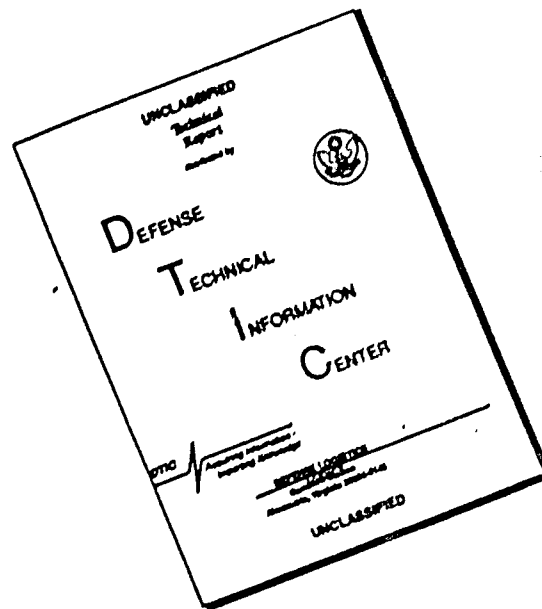
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To: Office of Naval Research
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Washington 25, D. C.

Attention: Head, Air Branch, Naval Sciences Division

Via: Bureau of Aeronautics Representative
Palo Alto, California

Subject: Propelloplane Transport Aircraft Study, Contract
Nonr 1657 (00), Final Summary Report dated 15 May
1946, Transmittal of.

Enclosure: (a) Five (5) Copies of Subject Report.

1. The final summary report of the Propelloplane Transport Aircraft Study, Contract No. Nonr 1657 (00), is submitted herewith. Delivery to other agencies and contractors is being made in accordance with the attached distribution list.

HILLER HELICOPTERS

RA Wagner

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FINAL
SUMMARY REPORT

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Contract No. Year 1955 (1)
Report No. Summary Report
Title Propellerless Transport Study

Date May 15, 1956

Approved

A. Stuart III
A. Stuart III

By

M. Guerrieri
M. Guerrieri

Approved

R. Wagner
R. Wagner

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Propelloplane Transport Study
Contract No. 1657 (00)

Summary Report
15 May 1957

SUMMARY

The theoretical and experimental justification for the performance, stability and control of tilting-wing Propelloplane is contained in earlier NACA wind tunnel and free flight model tests and theoretical investigations conducted by Miller Helicopters as part of this study. The significant conclusion reached as a result of these researches is that the wing, in transition from hovering to forward flight, contributes immediately to the lift of the aircraft and makes possible equilibrium in flight at very low forward speeds. Of great importance is the fact that the thrust and power required during transition decreased steadily from the maximum value required in hovering.

The practicability and all-around best possibilities of the propeller-lifted, tilting-wing aircraft as a solution to the operational problem of providing air mobility for combat troops and cargo is demonstrated by two preliminary designs of Propelloplane Transports which employ engines scheduled to be available in 1957 and 1960, respectively. A third design, based on the estimated characteristics of engines that will become available in 1965 is developed in considerable detail to show the outstanding performance improvements that may be expected due to improvements in engine performance alone.

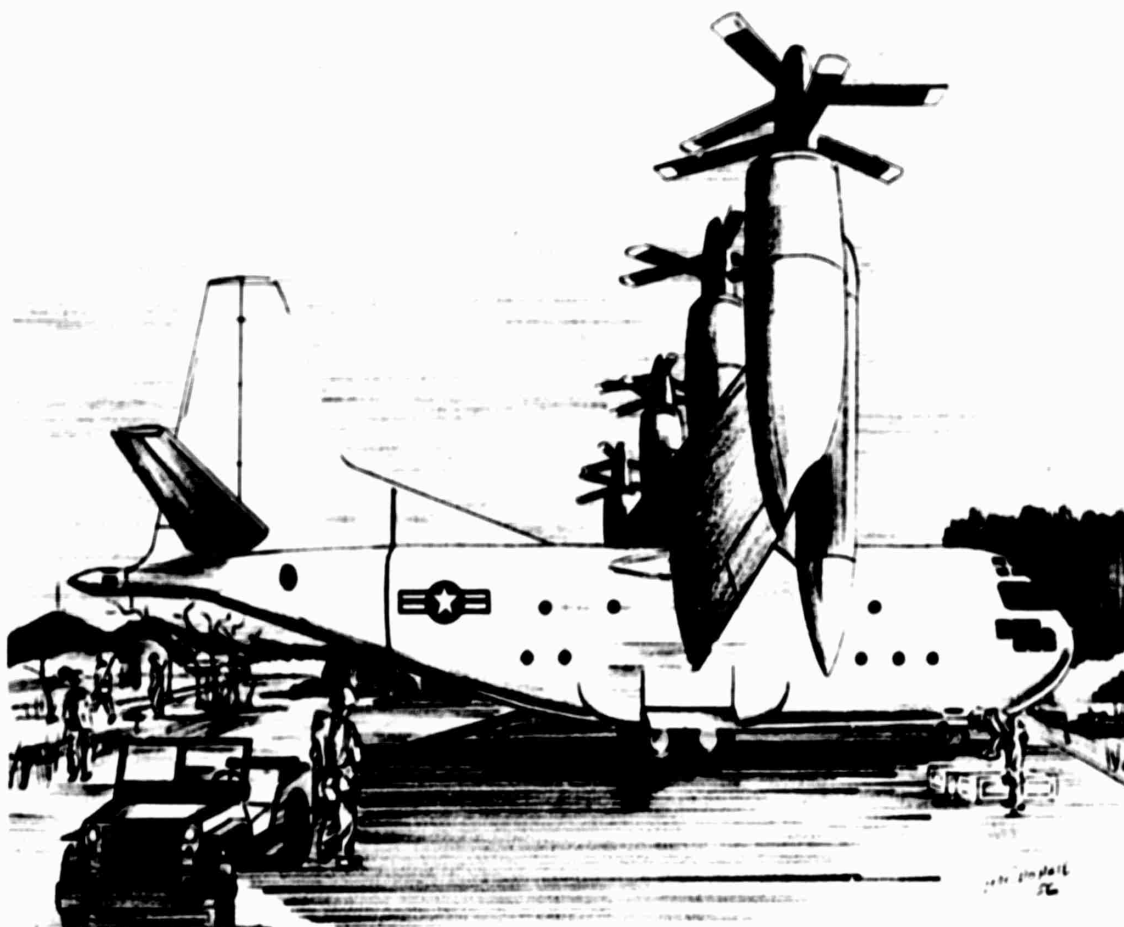
Model 1048-A, the 1957 aircraft, performs the specified mission without compromise and at a design gross weight of 71,250 pounds.

Model 1048-B, with Allison 560-B1 engines, scheduled to be available in 1960, and using water injection, when necessary, to permit meeting the hover ceiling requirements, also performs the specified mission but at a take-off gross weight of 101,000 pounds.

Model 1048-D is identical to Model 1048-A except for the engines, gear boxes and propellers. Eight Allison 501-D2 gas turbines, scheduled for production in 1958, drive four dual-rotation, eight-blade propellers approximately 19 feet in diameter. These propellers use a currently available Curtiss-Wright blade design. By using water injection and taking off at an overload gross weight of 83,600 pounds, Model 1048-D can carry a payload of three tons, with a radius of action of 310 miles, assuming take-off from 6000 feet altitude and 95°F. With standard temperatures at this altitude, Model 1048-D would be able to carry the full four ton payload the entire radius of 425 miles. This machine, is therefore, recommended for immediate development.

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Table I. Group Weight Statement
Table II. Leading Particulars
Table III. Performance Characteristics

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Drawing No. 1048A-002 Inboard Profile
Drawing No. 1048A-003 Wing Hinge and Actuator System
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Propellerplane Transport Study
Contract Nonr 1657 (00)

14 Jan 1955
Summary Report

INTRODUCTION

After World War II the first successful VTOL aircraft, the helicopter, was energetically developed. It had received its baptism of fire in small numbers during the last months of the war, but the Korean conflict became the proving ground for large scale testing of the helicopter in combat, and it was there that it earned recognition of its indispensable qualities for military transport missions. By the same token, the inadequacies of reciprocating engine driven, rotor-lifted aircraft, for use in many future combat transport situations was observed by Army and Marine Corps leaders.

Concurrently, post-war development of turbo-jet and turbo-prop power plants opened the way to the possibility of designing vertical rising aircraft not involving the use of large diameter, articulated or semi-articulated rotors, and many schemes were advanced for exploiting this possibility. The most impressive early results were the two Navy VTOL fighters, the XFV-1 and the XFV-1.

In 1954 personnel of the Army Transportation Corps, recognizing that comprehensive engineering studies were required for guidance in future development of combat transport aircraft, initiated a broad cooperative program of study and evaluation of various VTOL and STOL aircraft concepts.

Because of its prior history of interest in propeller-lifted aircraft and as a pioneer exponent of the tilting-wing turbo-propeller lifted concept, Hiller Helicopters was awarded in March, 1955, Contract Nonr-1657 (00) to study and evaluate the development problems involved in this segment of the VTOL aircraft program.

In order to make possible a valid comparative evaluation of the several aircraft designs issuing from the different groups involved in the program, a statement of the operational problem and the uniform design conditions to be used as a basis for study was formulated at a meeting of the Military and contractor's representatives at the Office of Naval Research on April 27, 1955, and amplified by later meetings and directives.

Within the frame work established by specification and agreement, the primary objective of the work to be performed by Hiller Helicopters was to make a preliminary design of the optimum tilting-wing turbo-propeller lifted aircraft capable of accomplishing the specified mission. A summary of the results of that work is presented in this report.

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Propelloplane Transport Study
Contract Monr 1657 (00)

Summary Report
15 May 1956

SECTION I - DEFINING THE PROBLEM

A. MISSION REQUIREMENTS:

The operational problem and specified characteristics of the VTOL category of aircraft were stated as follows:

- | | |
|----------------------------------|---|
| a) Payload | 8000 lbs. out
4000 lbs. return |
| b) Take-Off Distance | 0' over a 50' obstacle |
| c) Cabin Size | 8' x 9' x Length Required for
35 Troops |
| d) Cargo | 35 Combat Troops or Equivalent
Weight of Vehicles or Equipment |
| e) Hover Ceiling | 6000' Altitude and 95°F. Ambient
Temperature |
| f) Minimum Cruise Speed | 300 MPH |
| g) Radius of Action | 425 Statute Miles |
| h) Flight Profile | Cruising Altitude Optional Except
for 20% of Radius Adjacent to
Destination at Sea Level |
| i) Landing Surface | For Rolling Take-Off
$\mu = .2$; UCI = 15 |
| j) One Engine Out
Performance | Aircraft to Remain Controllable
following failure of One Engine
and be able to make a "Controlled
Crash" Landing |

Several items of considerable importance in their effect on the parameters of the aircraft were necessarily unspecified in order to accommodate a wide range of types. In regard to these optional conditions, assumptions were made which seemed compatible with the mission and type of aircraft being considered by this contractor:

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Propelloplane Transport Study
Contract Nour 1657 (00)

Summary Report
15 May 1960

1) Hover Duration:

The time required to takeoff, climb vertically to 50 feet altitude and convert to forward flight was assumed to be one minute. A total time of 4 minutes per mission was allowed for take-offs, conversions, and landings. Measurement of the time required for fully loaded Douglas DC-6 and Lockheed Constellation aircraft to accelerate from rest and climb to approximately 50 feet indicates that the assumed time of one minute is excessive. The low power loading of VTOL aircraft compared to fixed wing airliners assures a much higher acceleration and indicates that under normal conditions considerably less time would be required. The wing tilt actuating mechanism was designed to tilt the wing 30° in 20 seconds.

2) Cruising Altitude:

Cruising Altitude has been arbitrarily limited to 25,000 feet to make possible safe operation without pressurizing the cabin. This assumption possibly imposes a penalty upon the design, because in addition to the usual performance gains associated with increased altitude, the increased propulsive efficiency of the propellers, which are necessarily too lightly loaded in forward flight at low altitudes, might more than compensate for the increased structural weight and pressurizing equipment. The effect of altitude was not included in selecting the parameters of the optimum aircraft, because it would increase the work required beyond our capacity in the scheduled period, and because the intended employment of the aircraft accents its low altitude capabilities. The effect of cruise altitude on mission performance for the final optimum design is shown in Figure 10.

3) Provision for Engine-Failure Safety:

The requirement for ability to make a "controlled crash" landing following failure of one engine is the least amenable to proof outside of actual experience. Our designs are based on the premise that if adequate reserve power is available to reduce the rate of descent to a moderate value following failure of one engine and reduction in power of one other engine as required to obtain trim, plus some small allowance for roll control, then interconnecting shafts may be dispensed with. The optimum aircraft will hover out of ground effect at 5400 feet altitude in the standard atmosphere with the most critical power section inoperative and the remaining power sections delivering normal rated power. The

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Propellerless Transport Study
Contract No. 157 (00)

Department of Defense
15 Mar 1956

Incidence of "controlled crash" landing is still a considerable risk. Under the most adverse conditions of hovering at 50 feet above the ground at 500 feet altitude and 200 F., abrupt failure of one power section followed by instantaneous application of military power from six of the remaining seven operative engines would result in a velocity of descent at impact of less than 20 feet per second.

4) Cruising Speed:

The specified maximum cruising speed of 30 miles per hour was assumed to be the actual cruising speed throughout the study. Power plant arrangement during cruising flight was the subject of a separate study aimed at determining the optimum division of (reduced) power among the eight installed power sections.

5) Load Factors:

Specification of limit load factors is necessary for those components of the aircraft whose weights can not be estimated from empirical formulae derived from existing aircraft. For the tilting-wing aircraft these include the wing weight and weight of hinges, actuating mechanism and control devices. Load factors closely approximating those specified by applicable Civil Aeronautics Authority requirements for aircraft of similar size and function were selected.

SECTION II - DESIGN VARIABLES

A. Configurational Variables:

The major alternative configurations considered in this study prior to the selection of the final design are illustrated in Figure 1. The most basic of these is the number and arrangement of power plants, propellers, and nacelles. Preliminary weight estimates indicated that the two nacelle configuration was inferior to the four nacelle configuration in aircraft larger than approximately 60,000 pounds, and more detailed recent studies made in connection with another model indicate that, depending upon the hover ceiling and power plant characteristics assumed, this weight may be as low as 40,000 pounds. Practical considerations, such as maintaining moderate propeller diameters, reducing gear box sizes, and eliminating the interconnecting shafts, also, influenced the decision to use four nacelles.

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Propelloplane Transport Study
Contract Nonr 1657 (3)

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17 May 1961

Of the two alternative four-nacelle configurations illustrated, the four-engine version with interconnecting shafts unquestionably suffers a weight penalty compared to the eight-engine non-interconnected configuration. However, if the interconnecting gear boxes and shafting is designed to have only a short life for full emergency load and in normal operation carries only the unsymmetrical load due to control movements and transient variations in propeller load due to yawing, different rates of pitch change between the separate propellers, and other short term effects, the system is not prohibitively heavy. However, the undesirable cost, complexity, maintenance difficulties, and vibrations associated with long shafts led to the decision to settle on the four-nacelle, eight-engine configuration as the basic design for this study.

Four methods of providing for auxiliary longitudinal and directional control in covering are illustrated. The method involving the use of bleed air from the main engine compressors was clearly ruled out due to the detrimental effect on engine efficiency of the large quantities of bleed air required. Our estimates indicated that from a weight standpoint tail rotors and tail jets plus the fuel required for their operation were roughly equivalent with some advantage accruing to the more efficient thrust producing rotors. However, in our judgment the advantage was not great enough to warrant the complication, drag in forward flight, vibration, and maintenance difficulty incurred by their use. The high specific thrust, small size turbo-jet engines now being produced are ideally suited to this short life, intermittent operation application.

Three fuel storage locations are illustrated, each having some advantages. For maximum aerodynamic and structural efficiency the wing tip location is favored. In the final optimum design the outboard nacelles were located at the tips so that the underslung tanks were required. This position aids in obtaining proper center-of-gravity movement of the aircraft during transition from vertical to forward flight and is favored from a safety and constructional standpoint over the fuselage hold location.

The selected landing gear arrangement consists of a wheel and skid combination which provides a rolling contact area having a Unit Construction Index of 41 and is adequate for use on flexible pavements and landing mats. With the skids lowered for vertical landing on unprepared surfaces, the contact area is sufficient to give a pressure approximately the same as that of a truck, 3/4 ton, 4 x 4, weapons carrier.

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1 May 1951

For an all-wheel landing gear, estimates indicate that the multiple, small, high pressure wheels weigh less than the conventional dual tandem large, low pressure arrangement, for the same U.C.I. The compromise skid and wheel arrangement is appreciably lighter than either of these arrangements.

The selection of an unpressurized cabin has been previously explained.

The selection of dual rotation propellers was arrived at as part of the optimization analysis of the basic parameters.

B. Parametric Variables:

The number of parametric variables subjected to a systematic variation as part of the process of selecting the optimum aircraft included all of the fundamental performance parameters and as many additional variables as permitted by the inevitable necessity of rationing our efforts to accomplish the study objectives within the period available. The following parameters were considered:

- a) Gross Weight
- b) Wing Loading
- c) Aspect Ratio
- d) Propeller Disk Loading
- e) Propeller Tip Speed
- f) Number of Blades
- g) Blade Activity Factor

C. Specification of Furnishings and Equipment:

It has been observed that considerable variation exists among the various groups concerned in the present program as to the weight allowance made for the aircraft furnishings and fixed equipment. In this study a conscientious effort was made to make weight provision for all the numerous pieces of operational equipment ultimately demanded in a fully developed military transport aircraft. The list of items considered was adapted from the standard furnishings and equipment groups of currently operational military cargo aircraft; therefore this group weight is subject to review by the procuring agency if it appears that certain items are superfluous in the intended employment of the aircraft.

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SECTION III - RESULTS

With the tools and methods developed in the work reported in the preceding section, three preliminary designs of tilting-wing turbo-propeller lifted aircraft have been produced. These are estimated Propellerplane Transport Models 10h⁸-A, 10h⁸-B, and 10h⁸-D, and represent aircraft that could be available in 1965, 1960, and 1958, respectively.

The study was principally directed toward the design of Model 10h⁸-A. At the request of the procuring agency, additional studies were made to develop Model 10h⁸-B, designed around the Allison Model 550-B1 gas turbine, scheduled for availability in 1960. Model 10h⁸-D was included to show how minor revisions in the specified mission requirements would permit immediate development of a practical machine.

A General Arrangement Drawing of Model 10h⁸-C, a two-nacelle configuration, is included for information. Work on this design was not carried beyond a preliminary weight estimate when it became obvious that it could not be competitive with the four-nacelle configuration.

General Arrangement Drawing 10h⁸-A-001 and Inboard Profile Drawing 10h⁸-002 apply specifically to Model 10h⁸-A. Similar drawings for Models 10h⁸-B and 10h⁸-D were not prepared because of their nearly identical features. The differences in dimensions of the three models are listed in the table of leading particulars.

A. DESIGN FEATURES:

1. Pilot's Cabin:

Weight and space provisions have been made for a pilot, copilot, and flight engineer. Access to the pilot's cabin is provided through an integral side door and ladder or through the door leading to the cargo compartment. An emergency escape hatch and tube to the bottom of the fuselage is also provided. Weight and space provision for the electronic and communication equipment is made on the flight deck adjacent to the flight engineer's station.

2. Cargo Compartment:

Cargo compartment dimensions are 8' x 9' x 33', and it has a capacity of 35 infantry troops or 18 litters or one truck, 1-1/2 ton, 6 x 6, cargo and personnel carrier, or 3 trucks, 1/4 ton, 4 x 4, utility. The large, unobstructed, rear loading ramp may be lowered for ground loading or raised to truck bed height.

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3. Landing Gear:

The fully retractable combination skid and wheel landing gear is proposed as the lightest, simplest arrangement for providing adequate flotation for landing on soft, unprepared areas and adequate tire contact area for operation from paved runways. The skids are hydraulically retractable to the forward flight landing position. The landing gear is accessible from within the aircraft.

4. Wings:

The eight power sections are geared in pairs to four dual-rotator six-bladed propellers. Firewalls between the power sections and individual oil tanks and coolers are provided for maximum protection against engine failure. Overrunning clutches between the power section output shafts and gear box input shafts provide for disengagement of a failed power section or for voluntary shut down of power sections in cruising.

5. Wing-Tilt Mechanism (Drawing 1048A-003):

Structural efficiency of the wing is not impaired by the hinged connection to the fuselage. The large cross sectional area, two-spar, tapered, cantilever wing beam is continuous from tip to tip. The wing is hinged at the rear spar, located at the 50 percent chord station. Coordinated ball bearing screw jacks, powered by a central 40 horsepower hydraulic motor, tilt the wing through its 90° tilt range in twenty seconds, the approximate time required to accelerate the aircraft from hover to airplane flight speed. An emergency standby electric motor and hand crank are available to actuate the screw jacks in the event of hydraulic system failure.

The critical compression load on the screw jacks was found to occur on the ground when a horizontal decelerating force is applied to the aircraft with the wing in the vertical position. Hydraulically actuated lock-pins secure the wing in the airplane configuration.

6. Control Functions (Drawings 1048A-004 and 1048A-005):

In addition to the usual airplane surface controls, Models 1048A, 1048B, and 1048D are provided with auxiliary means for control in hovering and low speed forward flight. Longitudinal and directional control are provided by directing the exhaust gases of a small turbo-jet engine, mounted in the tail of the aircraft. Lateral control is obtained by varying differentially the power output of the power sections on opposite sides of the aircraft in response to motions of

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to pilot's control of it. In the case of ailerons, it is a more difficult matter for the ailerons to move, because if they were to function in their normal manner, various moments caused by it, other than the propeller roll, would be the ailerons' roll. Now, therefore, the pilot applies lateral control with a. counterbalance, or forward, lift, to the airfoil surface, that associated with lateral control is now rigidly established. Diagram 10 A-B, it must be noted, shows the unusual nature of aerodynamic moment relation. Of importance here is that the relationship between wing position and the nature of aileron action is a gradual motion, and it is only as the wing is altered to such an extent as to form a new aileron position, that the wing is in a position to be altered.

Views A-A and B-B of this drawing show how large numbers of control cables can be routed from the discplate to the ring with negligible change in cable tension occurring due to ring tilting. It is found that if 1/4 inch diameter control cables were assumed, the change in tension due to any tilt motion is less than 200 pounds during the cycle. The tensions at the beginning and end of the cycle are equal.

Drawing 12, A-005 shows how the exhaust gases from three turbo-jet engines converge in a common nozzle and are ejected out the tail jet through bullet-type valves. Before converging the pressure energy of the flow from each engine has been converted to velocity so that back flow cannot occur through a stopped or failed engine. Any two of the three installed units have sufficient capacity for control in the most critical flight conditions. These turbo-jets are operated only during the take-off, conversion, and landing. They may also be used as auxiliary power sources for starting the main engine.

B. LEADING PARTICULARS AND PERFORMANCE CHARACTERISTICS:

Model 1048A and Model 1048D are identical in design except for the installed power plants and propellers. Model 1048A is the optimum, i.e., the minimum gross weight aircraft, capable of accomplishing the mission using engines having the characteristics which are estimated to be attainable by 1965. Model 1048D is based on the guaranteed characteristics of the Allison 501-D⁹ engines scheduled for production in 1958 and takes advantage of the increased performance obtained by the use of water injection. By making the initial take-off with water injection and with a 20 percent overload, Model 1048D is able to accomplish a reduced mission which is compared graphically with the specified mission

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in Figure 2. The propeller blades specified for Model 104^B are components of a Curtiss-Wright propeller currently in production. Model 104^D represents, therefore, an immediately developable, practical Propellorplane transport aircraft.

Model 104^B represents a close approximation to the optimum aircraft based on use of the Allison 40-B1 gas turbine scheduled for production by 1960, and using propellers which are smaller than designs currently being developed for use by 1960. By using water injection, Model 104^B can perform the complete mission without compromise. The comparative weights of Models 104^{BA}, 104^{BB}, and 104^{BD} are shown in Figure 3. Complete Group Weight Statements for each model are tabulated in Table I. Figure 4 shows the percentage weight breakdown of Model 104^{BA}. The weight of the turbo-prop engines, their reduction gearing, the lifting propellers, and the tail turbo-jet engines, grouped together as a power plant weight, becomes almost equal to the airframe and controls weight. 30 percent of the gross weight is still available for useful load at the stringent design vertical take-off condition of 95° at 5000' pressure altitude. This figure compares with perhaps about 15 percent for a normal airplane.

The most forward and most rearward c.g. positions anticipated are shown on Drawing 104^{BA}-001. Payload shifts of 50 inches are included within these maximum c.g. travels of 10 inches and 16 inches for the wing level and wing vertical conditions, respectively.

The leading particulars of each model are shown in Table II.

A comparative performance summary is shown in Table III.

C. CHARACTERISTICS OF MODEL 104^{BA}:

The remainder of this section is devoted to a discussion of the outstanding characteristics of the optimum aircraft, Model 104^{BA}.

1. Basic Operating Characteristics:

Figure 5 shows how the low equilibrium forward speeds of the optimum machine increase approximately 20 miles per hour for each 10 degrees of forward tilt of the wing. This machine would thus be traveling about 60 MPH when the wing was tilted 30 degrees forward of the vertical.

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Hiller Helicopters' experience with the ducted fan flying platform has indicated that when a flow is forcibly directed, in that case by the propeller duct, in this case by the wing chord, the correspondence between air speed and angle setting is a most positive and precisely defined function.

Figure 6 shows how both the propeller thrust and required engine power both decrease as the wing angle is decreased from the 90 degree vertical position used in hovering and forward speed is gained. These desirable calculated basic characteristics have been generally confirmed by NACA test results. These curves based upon an analysis of this particular case and include the effect of mounting the outboard nacelles at the wing tips.

2. Propelloplane Stability and Control Characteristics:

The curved lines on Figure 7 show the fraction of gross weight that must be supplied as tail jet up or down force in hovering and the low forward speed portion of transition flight. No tail jet up or down force is shown to be required at wing angles-of-attack of 60 degrees or less. At this angle and lower angles and at the corresponding forward speeds of 60 MPH and more, the horizontal tail can generate enough pitching moment to trim the aircraft. The small magnitude of these required tail jet thrusts, based upon the results, and consideration of the favorable shift of the aircraft center-of-gravity as the propeller-engine-wing assembly is tilted forward, is noteworthy. Only 2 percent of gross weight is required in up or down jet thrust to trim the machine. Actually, ± 5 percent is made available even with one of the three tail turbo-jet engines inoperative to provide a substantial margin to handle unusual conditions and provide generous power to insure adequately high pitching angular acceleration and thereby the achievement of prompt control response.

In hovering and low forward speed flight we have provided angular acceleration control powers of at least 12 degrees/second² about all three axes. The imposition of a transient power increase of 12 percent on one outboard nacelle and a power reduction of 12 percent on the opposite outboard nacelle will give rolling accelerations of this desired magnitude.

Figure 8 shows how the thrust of a turbo-prop can be made to rise from its idling to its take-off power value within half a second after its power control has been advanced to the "full throttle" position. With propeller pitch change rates of up to 20 degrees per second being made available in propellers designed for turbo-prop engine applications, it is evident that adequately rapid controlled variation of propeller thrust can be provided.

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3. Mission Performance:

Standard mission performance characteristics are shown in Figure 9. The standard mission is a 1000-mile mission with a 1000-mile cruise, a 1000-mile climb, and a 1000-mile descent. (Reduction of mission time for a 1000-mile mission is 10 minutes.)

The performance of the Propelloplane is compared with that of a conventional transport aircraft in Figure 10. The standard mission is a 1000-mile mission with a 1000-mile cruise, a 1000-mile climb, and a 1000-mile descent. The standard mission is a 1000-mile mission with a 1000-mile cruise, a 1000-mile climb, and a 1000-mile descent. The standard mission is a 1000-mile mission with a 1000-mile cruise, a 1000-mile climb, and a 1000-mile descent.

Figure 11 shows the effect of the standard mission on the radius of action. The standard mission is a 1000-mile mission with a 1000-mile cruise, a 1000-mile climb, and a 1000-mile descent. The standard mission is a 1000-mile mission with a 1000-mile cruise, a 1000-mile climb, and a 1000-mile descent. The standard mission is a 1000-mile mission with a 1000-mile cruise, a 1000-mile climb, and a 1000-mile descent.

Figure 12 shows the effect of the standard mission on the radius of action. The standard mission is a 1000-mile mission with a 1000-mile cruise, a 1000-mile climb, and a 1000-mile descent. The standard mission is a 1000-mile mission with a 1000-mile cruise, a 1000-mile climb, and a 1000-mile descent. The standard mission is a 1000-mile mission with a 1000-mile cruise, a 1000-mile climb, and a 1000-mile descent.

SECTION IV - EVALUATION OF PROPELLOPLANE DEVELOPMENT PROBLEMS

Of the development problems that will be encountered during the evolution of the Propelloplane, several are common to all forms of airborne vehicles and only two can be identified uniquely with the Propelloplane type. Furthermore, some of the development problems are not really considered technical problems, because the level of technology is adequate to supply solutions for them under economic and strategic conditions warrant the expenditure of resources in their solution.

Problems that may be anticipated at present may be listed as follows:

- a) Propelloplane Development
- b) Propelloplane Development
- c) Turbine Development
- d) Auxiliary Control Turbo-Jets and Nozzles
- e) Wing Circulation Control
- f) Fuel System Design
- g) Cabin Pressurization
- h) Landing Gear Development
- i) Cargo Handling Methods

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Propeller-Engine Controls

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Propeller-Engine Controls:

In the aircraft design, a propeller is often considered the gross weight multiplier of the aircraft. The results of experimental results of the British turbine propellers, but in the United States, the results of the dual rotation propellers are in great favor of the slight-ly larger, dual rotation, dual rotation propellers.

In the aircraft design, a propeller is often considered the gross weight multiplier of the aircraft. The results of experimental results of the British turbine propellers, but in the United States, the results of the dual rotation propellers are in great favor of the slight-ly larger, dual rotation, dual rotation propellers.

Our study of the first-order propeller blade air shaft loading stresses during transition from hovering to forward flight indicates that for a Propelloplane having the transition flight characteristics of Model 10, the stresses are not critical. Again, only actual flight data in Model 10 can give positive assurance that this is the case, but for the present it appears that the Propelloplane is not one of the critical problems from a technical standpoint.

(1) Propeller-Engine Controls:

In addition to the usual devices for controlling turbo-propeller power plants, the Propelloplane requires means for varying the propeller blade pitch differentially on the nacelles on opposite sides of the aircraft to produce rolling control in response to motions of the pilot's control wheel during hovering and slow speed flight with the wing vertical. This would be accomplished by varying the power settings of the engines. The propeller's constant speed pitch control governing system would correspondingly alter the blade pitch, affecting a change in thrust. Changes in power of about ± 12 percent of normal rated power appear adequate to produce satisfactory rolling moment.

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Figure 1 has already been cited as indicating that the engine and the propeller pitch change mechanism of current designs are sufficiently responsive to power settings to provide satisfactory rates of control response. Development of suitable mechanisms to perform this function is required but offers no extreme difficulties.

A somewhat knottier problem is foreseen in the development of automatic devices for maintaining safe control following failure of a power section under the most critical hovering conditions. If, for example, one outboard engine section failed while the aircraft is hovering at 6000 feet altitude and 90° F., power should be re-routed in the opposite outboard nacelle and the remaining operative engines immediately advanced to military power. Normal pilot reaction, assuming that he is initially unaware of the emergency, would be to apply roll control to maintain level attitude and increase the power lever settings to maintain altitude. However, the normal range of roll control travel will normally provide about a 12 percent change in power settings, which corresponds roughly to the percentage by which military power exceeds normal rated power. Thus, application of full roll control will not be sufficient to trim the aircraft and automatic means of compensation for this situation and simultaneously signaling the pilot that an emergency exists should be developed. The feasibility of dispensing with inter-connecting shafts may be contingent upon successful development of such a device. Effort in this direction is strongly recommended.

c) Turbine Development:

In propeller-lifted VTOL aircraft propeller efficiency in forward flight is compromised by the essentially constant speed operation of the turbines, in order to maintain reasonable thermal efficiency. The optimum propeller for the cruising condition of a Propelloplane Transport would be about 15 feet in diameter. The larger diameter required for satisfactory static thrust in hovering results in reduced propulsive efficiency in cruising, if the same tip speed is maintained. If the tip speed is reduced 25 percent, the propulsive efficiency can be increased to about 90 percent. In this study propeller tip speed was considered a constant 900 feet per second, which was found to be the optimum compromise value for this mission. The development of twin-spool turbines which permit a wider variation in propeller operating speed without penalizing the turbine efficiency, would improve Propelloplane performance appreciably. This improvement must be weighed against the increased weight, cost, and maintenance associated with the more complicated free turbine engine.

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at higher altitudes would be more performance. If actual capabilities are taken into consideration, it is imperative to operate at low altitudes, and the emphasis should be given to the consideration of free test operations or other means (including two-speed transmissions) of lowering the propeller speed in cruise. On the other hand, if altitude is unrestricted, pressurizing the cabin and operating at altitudes where propeller performance at constant speed improves, may be the simplest way of compromising the divergent requirements of static thrust in hovering and good higher speed performance.

h) Dust and Noise Abatement:

This problem must be acknowledged in all low disk loading, vertical rising aircraft, and no problem of dust, in fact, considered, can be given at this time. It is incumbent upon the organization and strategists which understand the military advantage to be gained from the use of vehicles conferring true air mobility to combat elements to make plans and tactics suited to the shortcomings as well as the outstanding qualities of their weapons. For example, single operations or infrequent operations from grass-covered sites would probably be entirely satisfactory with Propelloplanes because of the low residual heat from the gas turbine exhausts and their relatively high location, while surfaces of loose sand or dry bare soil might be less suitable, principally due to piloting rather than mechanical difficulties. It is conceivable that light weight, air transportable fabric, plywood or metal landing mats, similar to the steel pierced plank of World War II air strips, would be adequate to prevent dust storms. Only small areas would be needed, which could be rapidly staked in place.

Of the several VTOL concepts only the helicopter or tilt-rotor convertiplane have lower disk loadings than the Propelloplane so that it appears that the problem of dust and noise control will be further aggravated by other types capable of this mission.

i) Modern Cargo Handling Methods:

Military sponsored studies of methods of handling air cargo currently in progress show that remarkable gains in transport capacity are attainable by using engineered, integrated cargo handling systems. The spectacular performance of the Propelloplane Transport would be improved more by modern method of loading and unloading cargo because of the lower block-to-block time. This item is cited merely to call attention to the work that is being done in this field and to suggest that it is appropriate to consider its implications at the earliest stages of planning for future cargo aircraft.

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CONCLUSION

The results of the study conducted by Miller Helicopters for the Army Transportation Corps under Contract Nona 165 (00) with the Office of Naval Research substantiate these conclusions:

1. The Concept of tilting-wing turbo-propeller lift-off and land aircraft is intrinsically sound and technically feasible.
2. The design and construction of a Propellor are capable of performing the specified mission is possible, using engines that are scheduled for production in 1960.
3. Design and construction of a Propelloplane capable of performing a slightly reduced mission, using engines scheduled for production in 1954, is possible, with a worthwhile reduction in the gross weight of the machine below that of the machine capable of the specified mission.
4. The development problems involved in the design and construction of a Propelloplane are numerous and lie in the state of our present technology.

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August 17, 1955
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APPENDIX - BIBLIOGRAPHY AND REFERENCES

Literature surveys, collection data, and developing analytical methods for handling the problems unique to wing-propeller combinations constituted the greater part of the work of this study. Correspondence and conferences with the major engine and propeller manufacturers and with personnel of the National Advisory Committee for Aeronautics, Ames, and Langley Laboratories were held frequently throughout the course of the study. Specific mention must be made of the assistance rendered by the Propeller Division, Curtiss-Wright Corporation, in developing an empirical method of estimating the effects of propellers. The information received from Dr. Charles Zimmerman of the Langley Aeronautical Laboratory in regard to the use of articulated propellers was also helpful.

The details of the sources of information and analytical methods used in this study are contained in Hiller Helicopters Engineering Reports submitted with the Progress Reports and with this report.

The following bibliography lists the Hiller Engineering Reports that form a part of the work submitted under Contract Nonr 1657 (9) and other references consulted in the course of this study.

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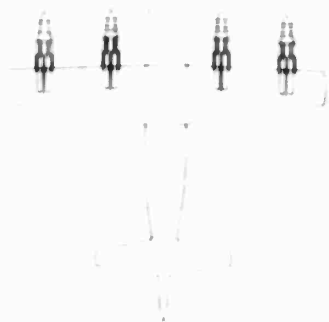
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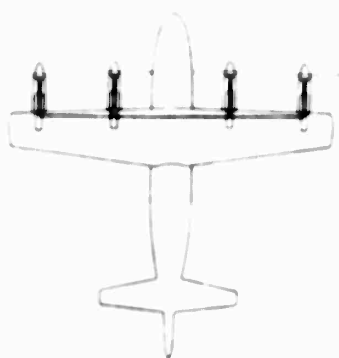
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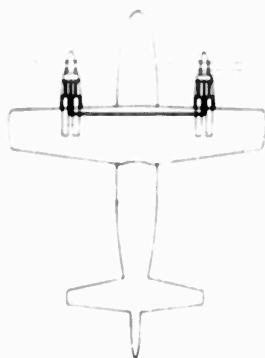
ENGINE AND NACELLES



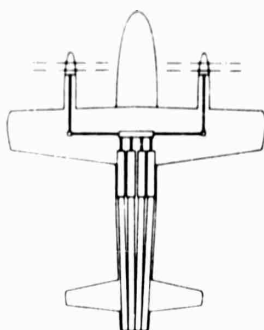
EIGHT ENGINES - FOUR NACELLES
NO INTERCONNECTING SHAFTS



FOUR ENGINES - FOUR NACELLES
INTERCONNECTING SHAFTS



FOUR ENGINES - TWO NACELLES
INTERCONNECTING SHAFTS



FOUR ENGINES - TWO NACELLES
ENGINES GROUPED IN FUSELAGE

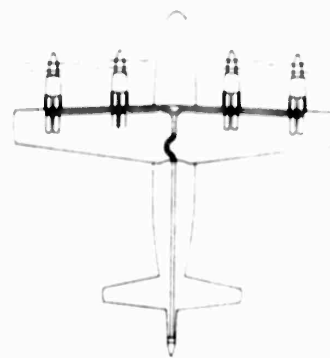
AUXILIARY CONTROL



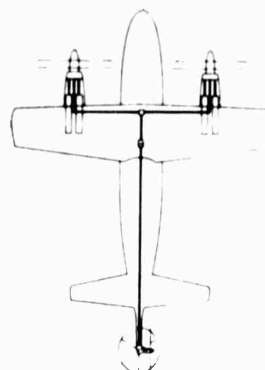
TAIL JET
AUXILLIARY TURBOJET ENGINES



TAIL ROTOR
AUXILLIARY TURBOPROP ENGINE



TAIL JET
MAIN ENGINE AIR BLEED



TAIL ROTOR
MAIN ENGINE DRIVEN

LANDING GEAR



DUAL TANDEM
WHEELS AND SKID

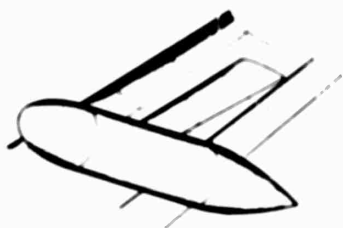


LOW PRESSURE
DUAL TANDEM WHEELS

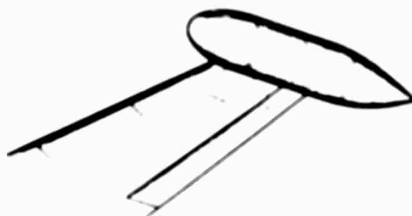


HIGH PRESSURE
MULTIPLE WHEELS

FUEL STORAGE



PYLON MOUNTED TANKS

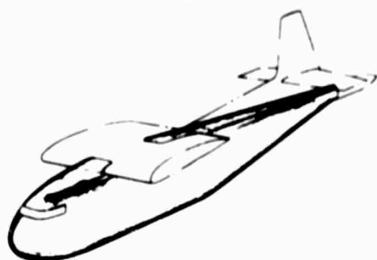


TIP MOUNTED TANKS



FUSELAGE TANKS

CABINS

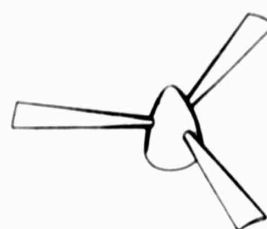


UNPRESSURIZED

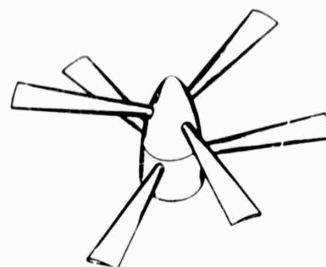


PRESSURIZED

PROPELLERS



SINGLE ROTATION



DUAL ROTATION

FIG. 1

MODEL 1048 D
PERFORMANCE

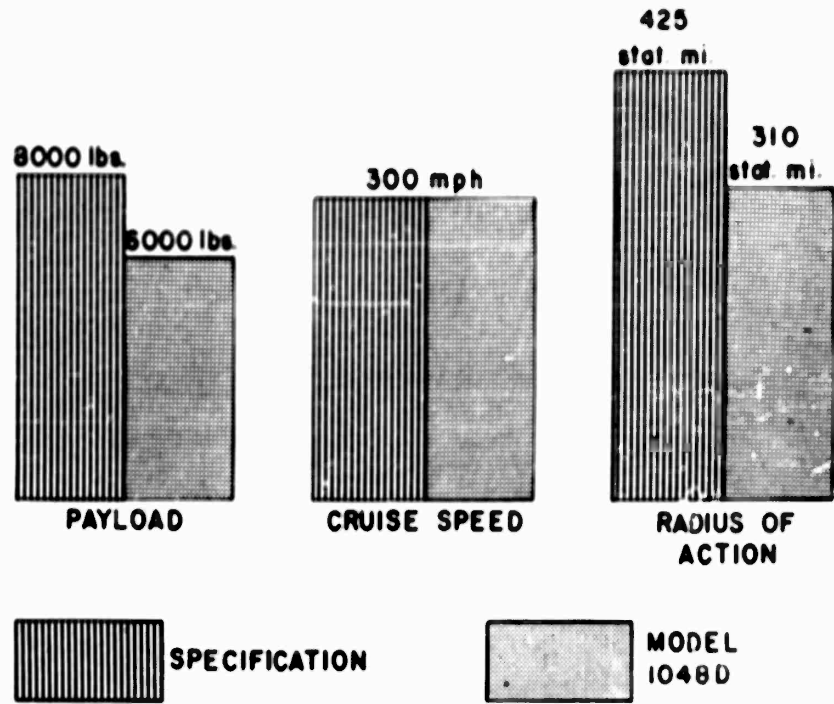


FIG. 2

COMPARATIVE WEIGHTS

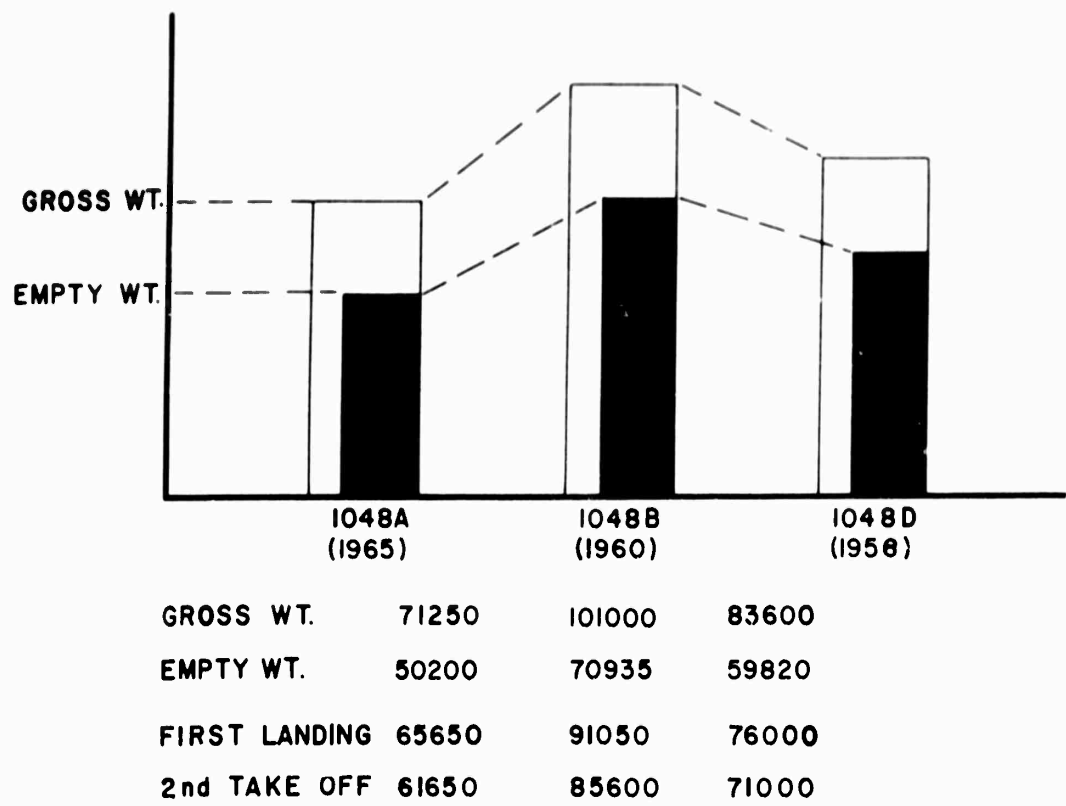


FIG. 3

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MODEL 1048A
PERCENTAGE WEIGHTS

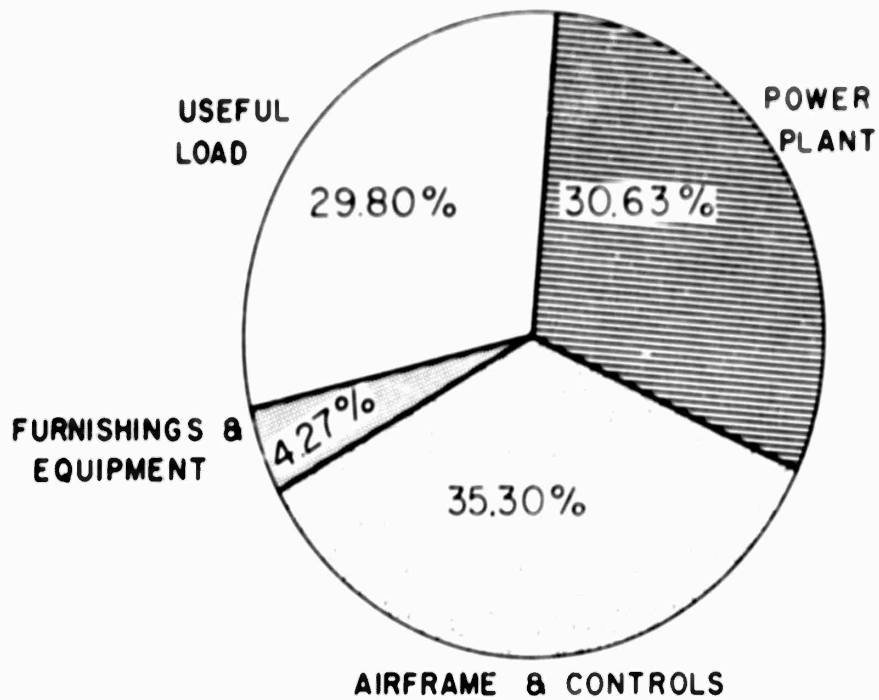


FIG. 4

MODEL 1048A
FORWARD SPEED VERSUS
WING TILT ANGLE

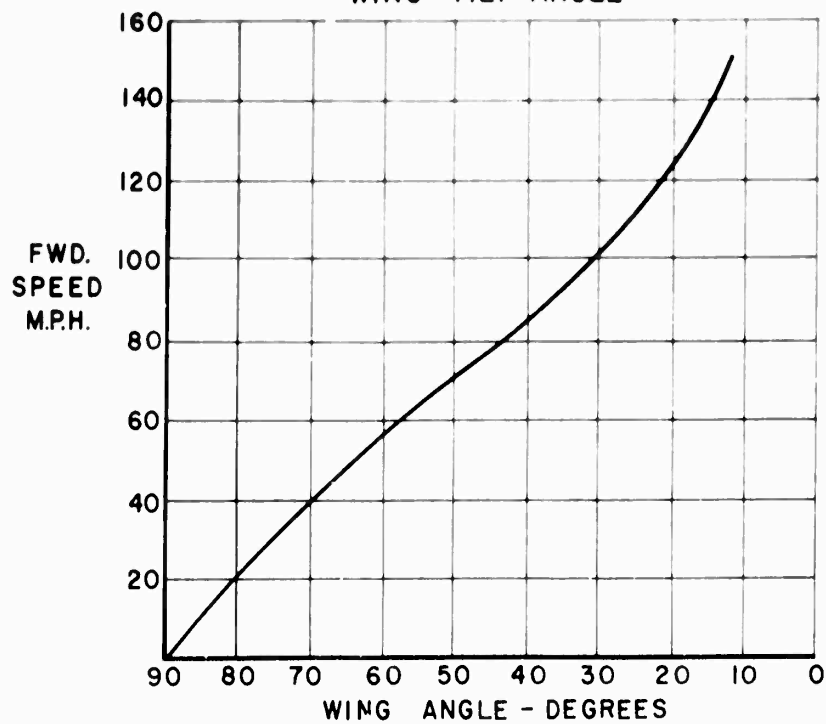


FIG. 5

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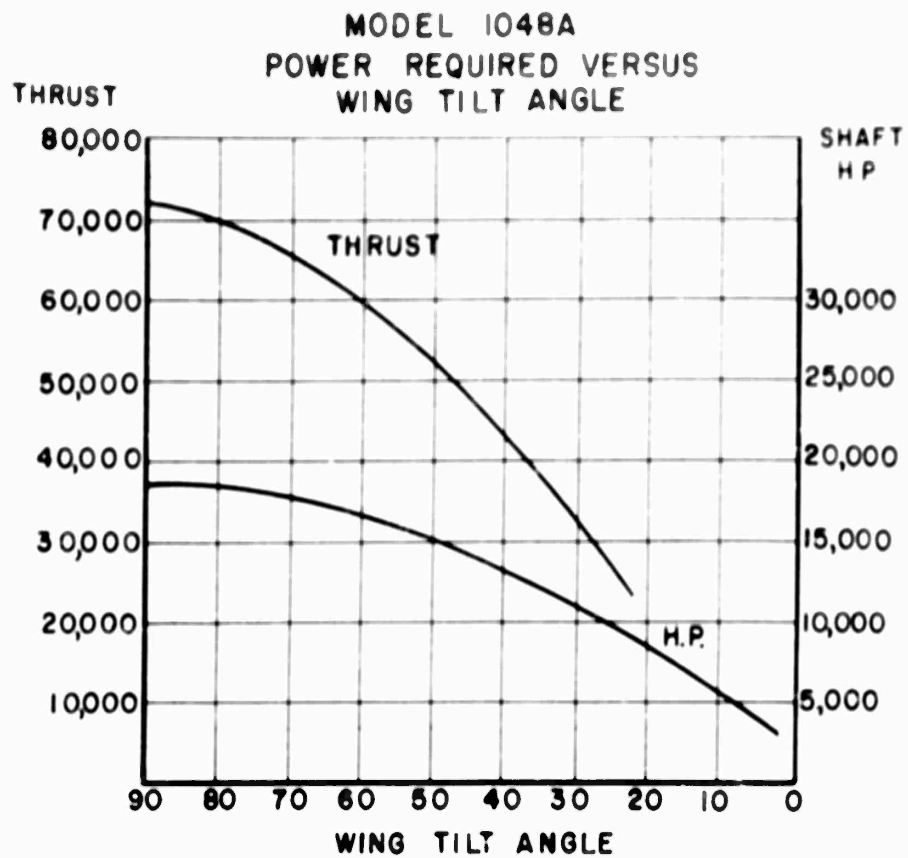


FIG. 6

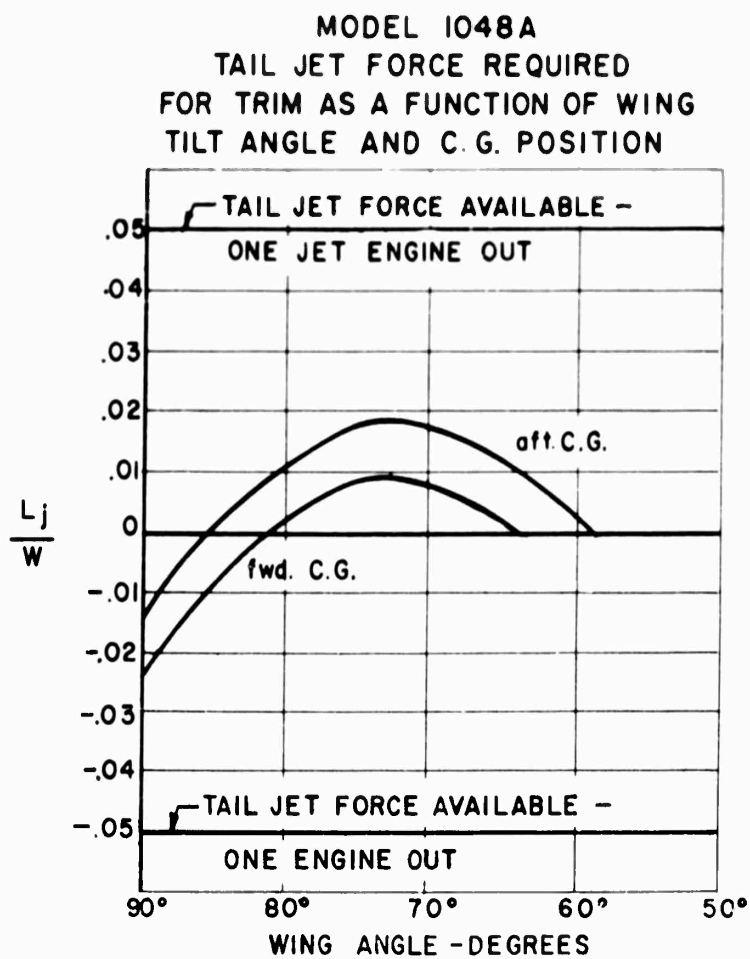


FIG. 7

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TYPICAL TURBINE TRANSIENTS FROM TEST RECORDS

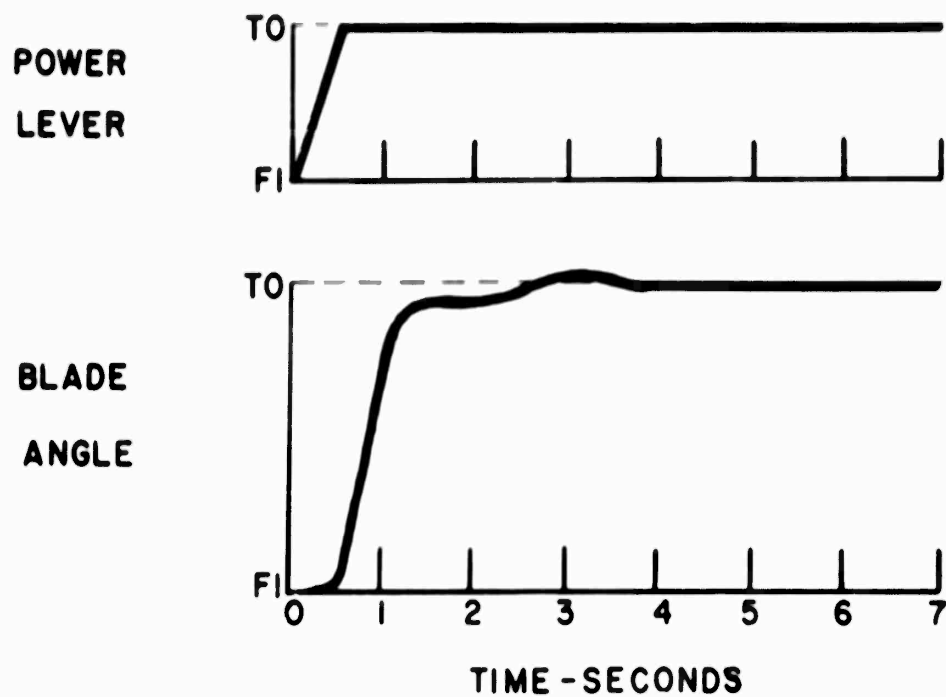


FIG. 8

MODEL 1048 A MISSION PROFILE

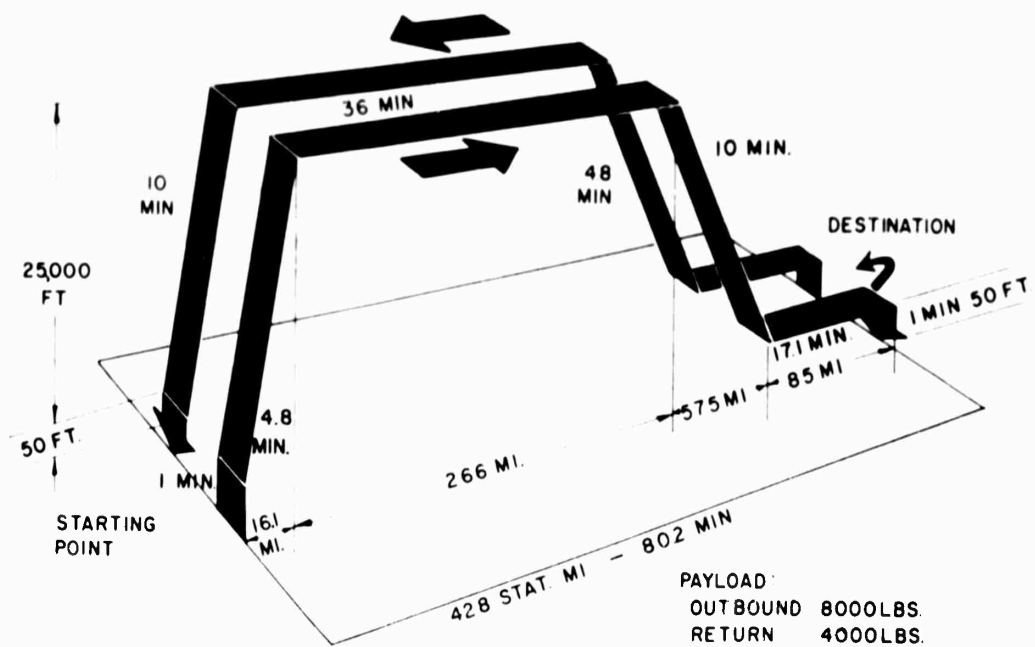


FIG. 9

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MODEL 1048 A

PAYLOAD-RANGE PERFORMANCE

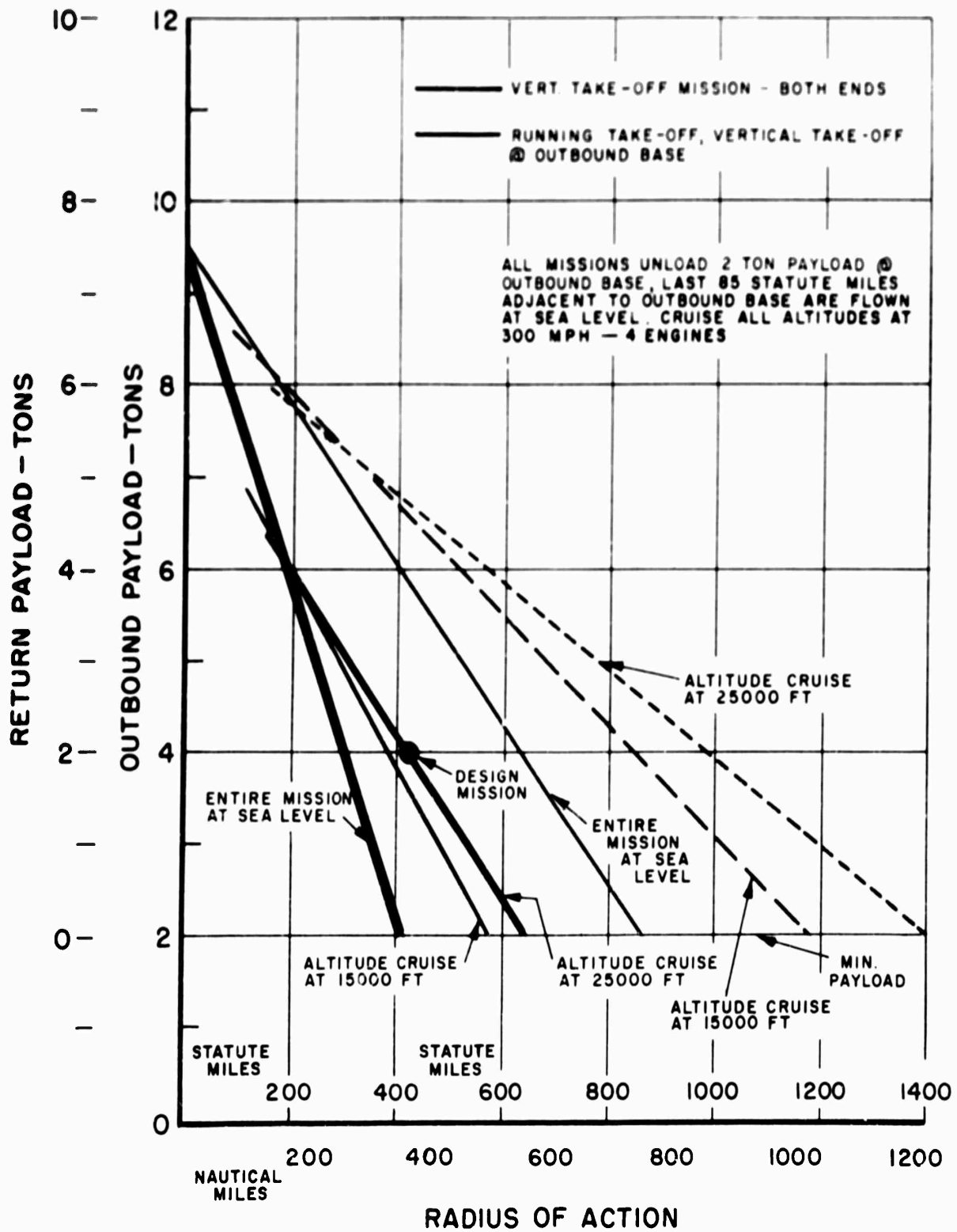


FIG. 10

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MODEL 1048 A

HOVER TIME VS RADIUS - SEA LEVEL, STD.

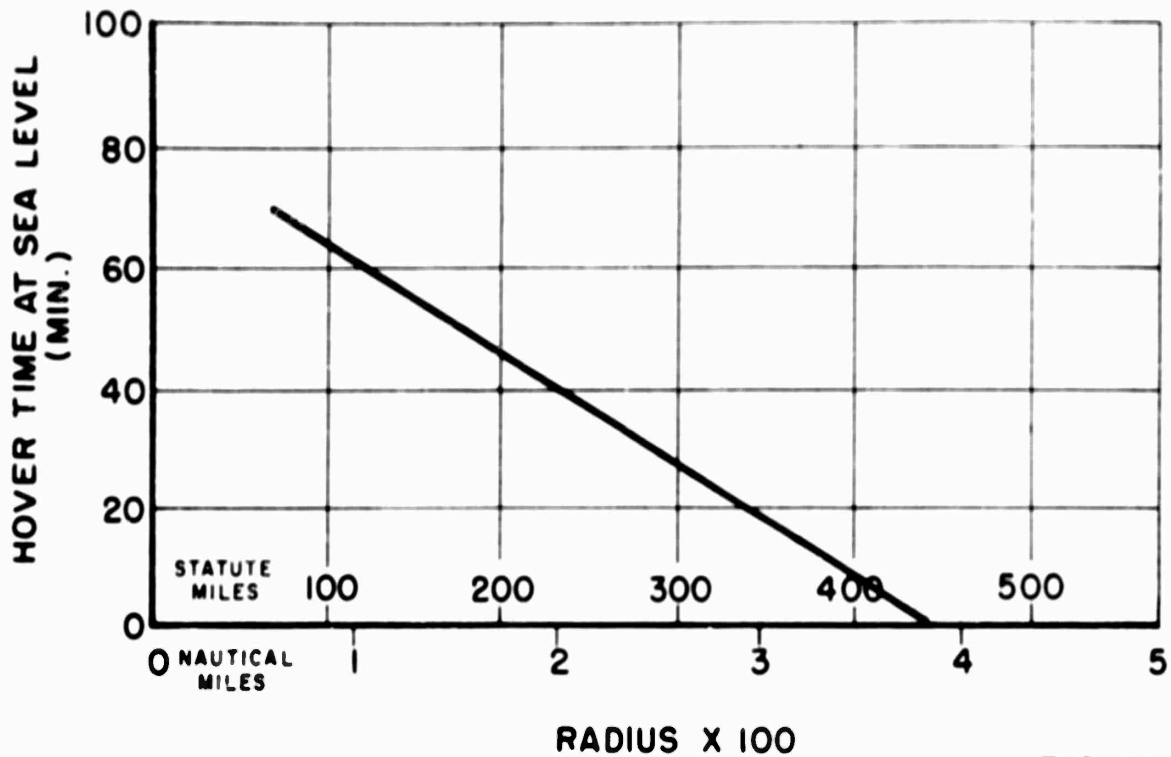


FIG. 11

MODEL 1048 A

TAKE-OFF DISTANCE VS GROSS WEIGHT

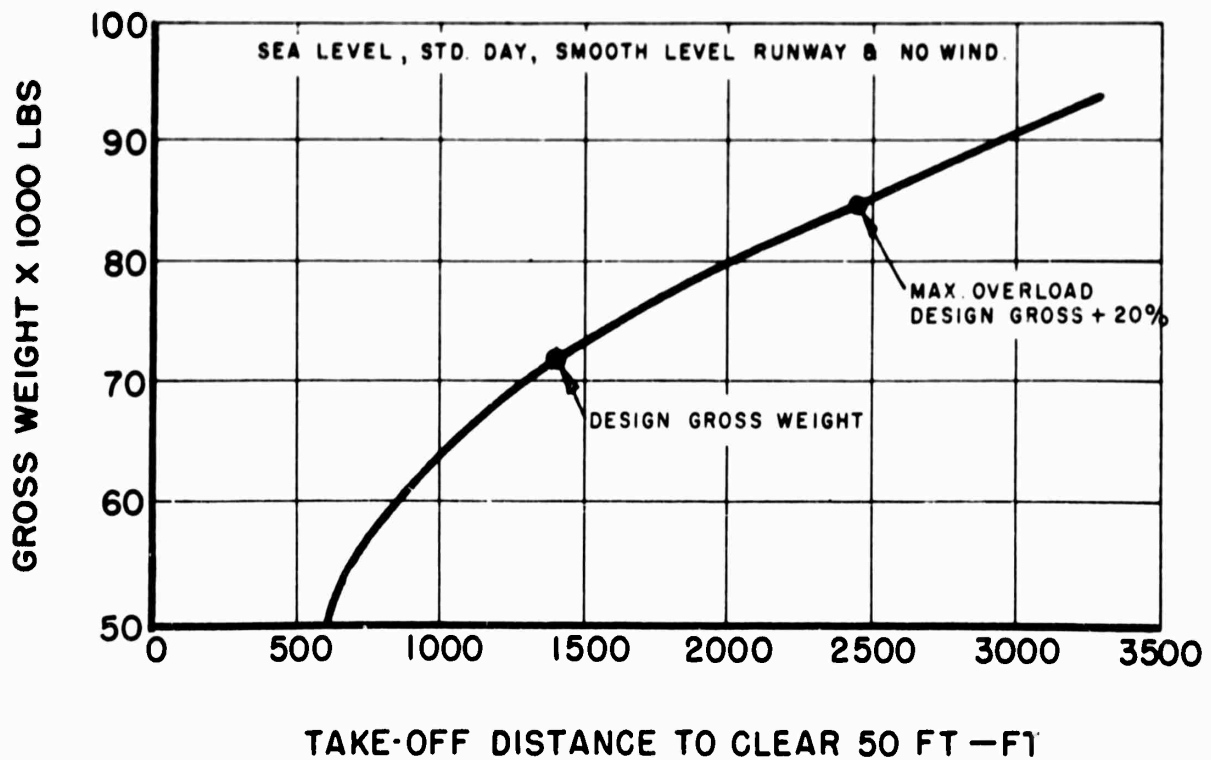


FIG. 12

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TABLE I
GROUP WEIGHTS

<u>TABLE I</u>			
1.	Wing Group		
2.	Tail Group		
3.	Body Group		
4.	Attaching Gear Group		
5.	Surface Controls Group		
6.	Cockpit Controls		
7.	Automatic Pilot		
8.	System Controls		
9.	Wing Tilt Mechanism		
10.	Engine Section or Mucelle Group (1)		
11.	Propulsion Group		
12.	* Engine Installation - Main (1)	1185	
13.	Transmission and Drives (1)	130	
14.	Fuel System	130	
15.	Water Injection System	0	
16.	Propeller Installation	600	
17.	Propellers (1)	300	
18.	Spinners (1)	30	
19.	Propeller Control	30	
20.	* Supplemental Control Engine Installation (3)	705	
21.	Supplemental System Control	400	
22.	Instruments and Navigation Equipment Group		
23.	Hydraulic and Pneumatic Group		
24.	Electrical Group		
25.	Electronics Group		
26.	Furnishings & Equipment Group		1500
27.	**Accommodations for Personnel	1185	
28.	Miscellaneous Equipment	130	
29.	Furnishings	45	
30.	Emergency Equipment	400	
31.	Air Conditioning and Anti-Icing Equipment Group		800
32.	Air Conditioning	200	
33.	Anti-Icing	600	
34.	Anti-Icing - Propeller (1)	300	
35.	Anti-Icing - Other	300	
36.	Weight Empty		5000
37.	Useful Load		71070
38.	Crew (3)	600	
39.	Fuel - Mission	11220	
40.	Fuel - Control	230	
41.	Oil	300	
42.	Troops and/or Cargo	8000	
43.	Design Gross Weight		71250
44.	Fuel - Overload		0
45.	Water - Water Injection		0
46.	Take-Off Gross Weight		71250

* Engine installations include air induction systems, exhaust systems, cooling systems, lubricating systems, engine controls, and starting systems.

**Accommodations for personnel includes: 3 crew seats & safety harnesses = 150 lbs.; 35 infantry men seats = 350 lbs.; toilet & washing facilities = 200 lbs.; and oxygen installation (including charge) for 38 men for 3 hours duration = 485 lbs.

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TABLE I
GROUP NET EFT STATEMENT

	CODE	10000-8		
1.		5545		
2.		1500		
3.		5055		
4.		5250		201
5.		2370		211
6.		100		
7.		215		
8.		1000		
9.		100		
10.		500		
11.		25000		
12.	12000			
13.	5000			
14.	2000			
15.	100			
16.	1310			
17.	12060		14000	
18.	200		100	
19.	150		150	
20.		1000		200
21.		500		100
22.		500		500
23.		615		500
24.		1125		1000
25.		500		500
26.		1800		1800
27.		1185		1185
28.		130		130
29.		45		45
30.		440		440
31.		800		800
32.		200		200
33.		600		600
34.	300		300	
35.	300		300	
36.		71435		49820
37.		21565		11130
38.		600		600
39.	11450		3600	
40.	1215		930	
41.	300		300	
42.	8000		6000	
43.		93000		71250
44.		6550		2150
45.		1450		2900
46.		101000		83000

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TABLE 1
LOADING PLATE DATA

Model	1965	1966	1967
Dimensions			
Length (Overall)	151' - 0"	151' - 0"	151' - 0"
Width (Outside of Propellers)	281' - 0"	183' - 5"	281' - 0"
Height (To Top of Vertical Fin)	35' - 0"	11' - 10"	35' - 0"
Weights and Loadings			
Empty Weight, Lbs.	50200	50200	50200
Payload, Lbs.	5000	5000	5000
Main Fuel, Lbs.	11220	11220	11220
Auxiliary Control Fuel, Lbs.	930	1416	930
Oil, Lbs.	310	310	310
Water-Alcohol, Lbs.	0	1000	0
Design Gross Weight, Lbs.	71250	71250	71250
Overload Fuel, Lbs.	0	1550	0
Take-Off Gross Weight, Lbs.	71250	72800	71250
Wing			
Span (Between Centerlines of Outboard Nacelles)	71' - 10"	61' - 12"	71' - 10"
Area, Square Feet	792	792	792
Aspect Ratio	6.5	6.5	6.5
Taper Ratio	2:1	2:1	2:1
Airfoil			
M.A.C.	10' - 10"	11' - 5"	10' - 10"
Tail			
Vertical Tail Area, Square Feet	211	251	211
Horizontal Tail Area, Square Feet	232	277	232
Propellers			
Diameter	18' - 7"	21' - 6"	19' - 1"
Number of Blades	6	6	6
Activity Factor	135	135	135
Tip Speed	900	900	900
Disk Loading	65.4	64.0	72.5
RPM	926	860	903
Landing Gear			
Wheel Base	24' - 3"	24' - 3"	24' - 3"
Tread	14' - 7"	14' - 7"	14' - 7"
Tires, Main, 8, Type VII	32 x 6.6	30 x 8.8	32 x 6.6
Nose 2, Type VII	29 x 7.7	30 x 7.7	29 x 7.7
Contact Area, Square Inches			
Skids Lowered	2546	3630	2546
Skids Raised	971	1380	971
Auxiliary Control Turbo-Jets			
Model	"1965"	MX2273	MX2273
Normal Rated Thrust, Lbs.	2200	2450	2450

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TABLE III PERFORMANCE SUMMARY

Model	1-1	2-1	3-1
Engines - 2 Each	"100"	Allegro	800
Normal Rated Power @ Sea Level	315	400	400
Military Power @ Sea Level	315	400	400
Speed, Miles Per Hour			
Stall, Sea Level, Std., Power	121	121	121
Cruise, Sea Level	210	210	210
Cruise, 2500 Feet	210	210	210
Maximum, Sea Level (75% NRP)	210	210	210
Maximum, 2500 Feet (100% NRP)	210	210	210
Rate of Climb, Feet Per Minute			
Initial, Sea Level (75% NRP)	1000	1000	1000
Maximum, 2500 Feet (100% NRP)	1000	1000	1000
Vertical, Sea Level (75% NRP)	300	300	300
Vertical, 6000 Feet, 950F., Military Power	200	200	200
Ceiling, Feet			
Hover, Std. Atmosphere, Maximum Power	1270	1270*	1270*
Service, NRP	1200	1200	1200
Hover			
% Maximum Power Required to Hover @ 6000 Feet, 950F.		35%	35%
Range, Miles			
Ferry @ 2500 Feet, Cruise Altitude, 30% Overload & 10% Reserve	3025	1500	1500
Radius of Action for Specified Mission	125	125	125

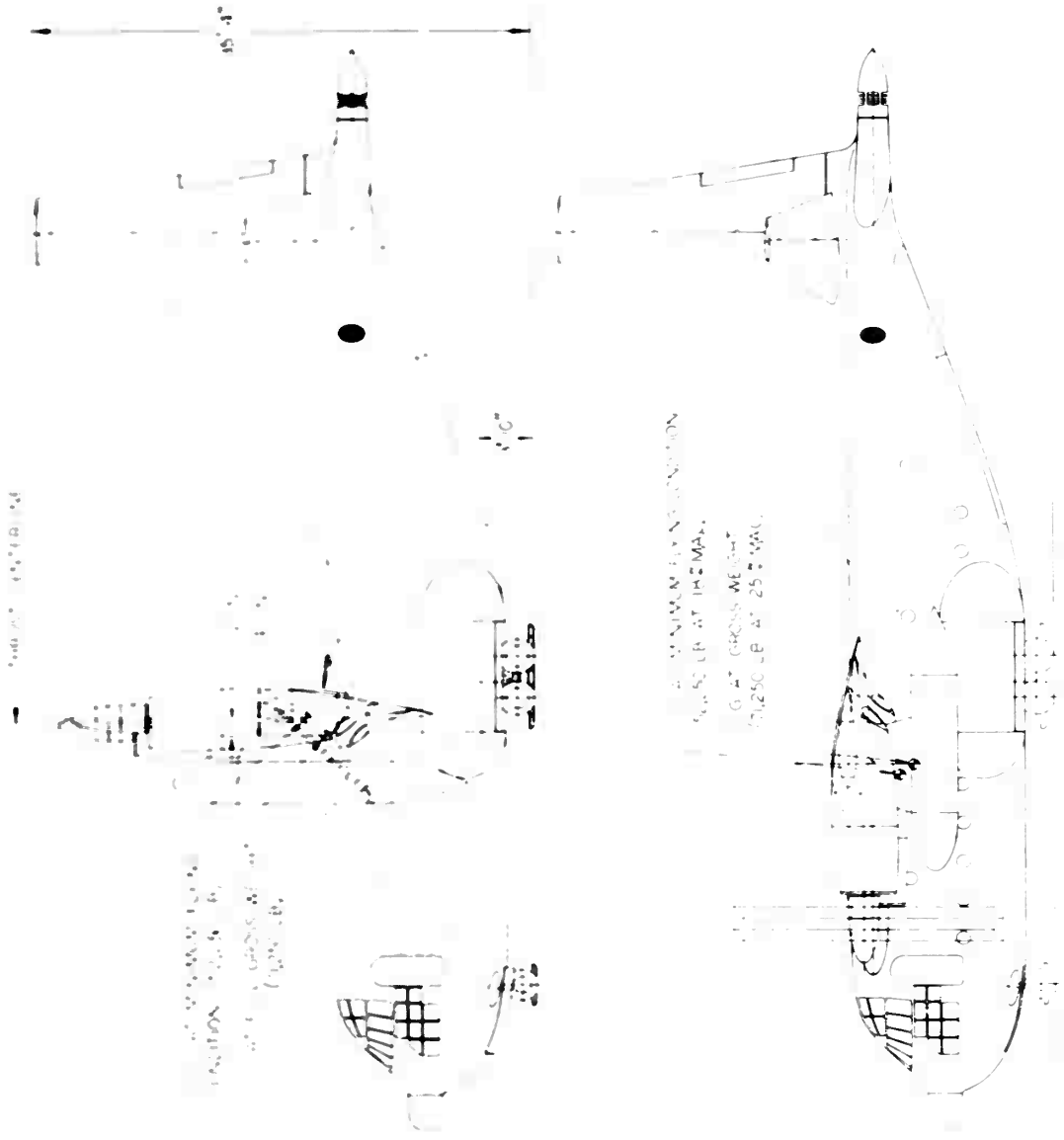
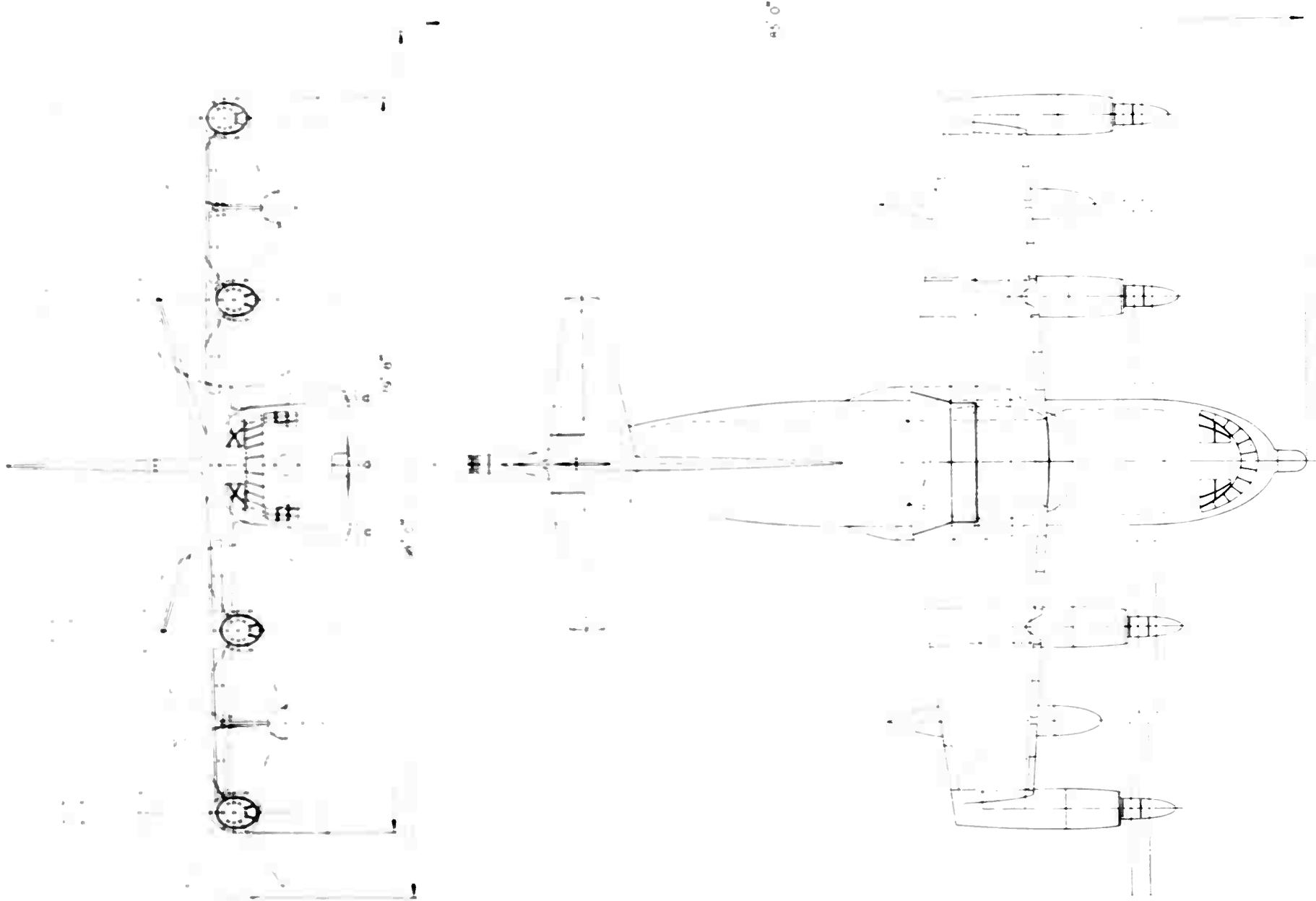
* Calculated at Design Gross Weight of 12,000 Lbs.

** Calculated at Take-Off Gross Weight.

• Water-Alcohol Injection Used.

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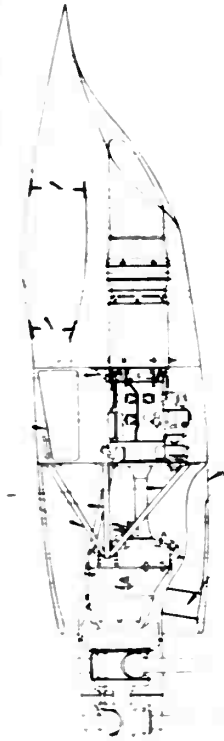
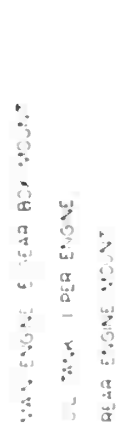
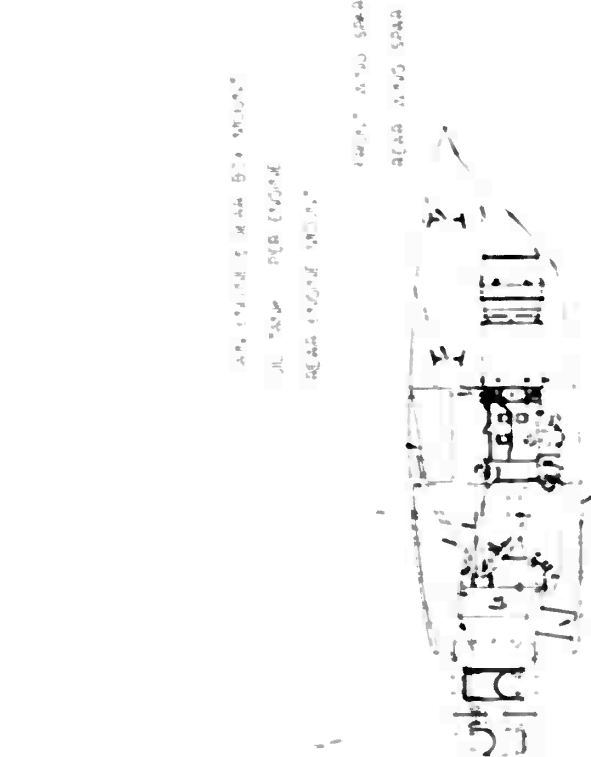
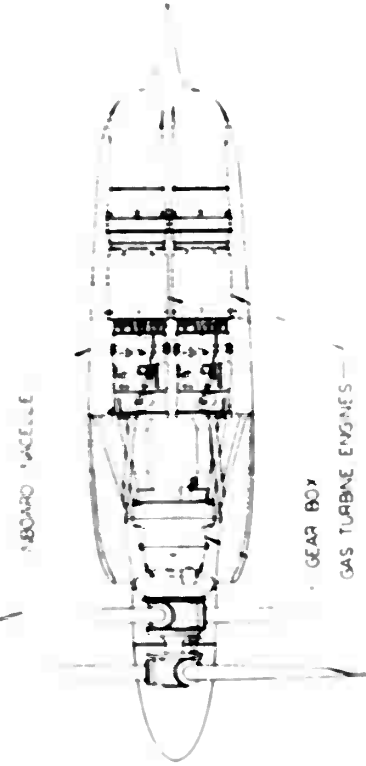
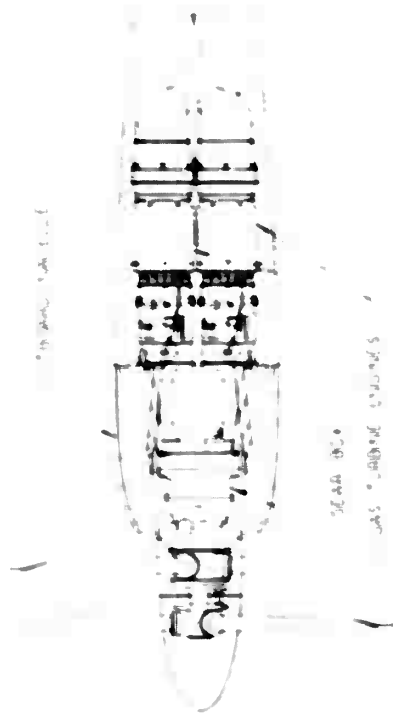
SCALE 0 50 100 INCHES

Miller Helicopters
PALO ALTO, CALIFORNIA

GENERAL ARRANGEMENT

SCALE	DRAWN	HOBBART	DATE	4-4-56	DRAWING NO.	1048A-001
NOTED	APPROVED		DATE	4-11-56		

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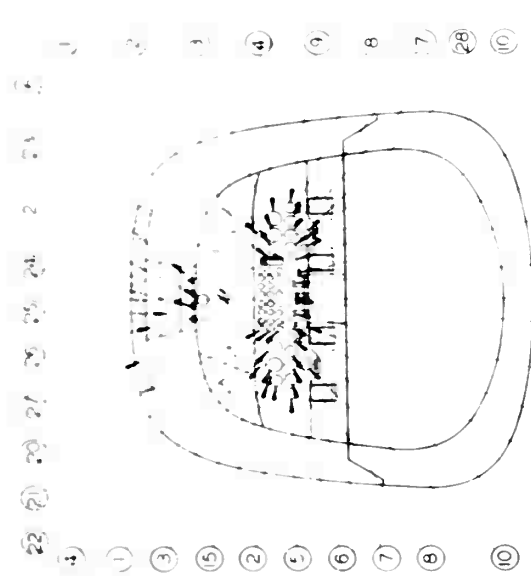
3. LOG
4. AIRSPEED
5. DIRECTIONAL INDICATOR
6. ALTITUDE INDICATOR
7. TURN & SLIP
8. ALTIMETER
9. CROSS POINTER
10. RATE OF CLIMB
11. STATION BEARING INDICATOR W/FREQ
12. STATION BEARING INDICATOR W/FREQ
FREE AIR TEMPERATURE
13. STANDBY COMPASS
14. DISTANCE MEASURING INDICATOR
15. RADIO ALTIMETER
16. RADIO CALL PLATE
17. LANDING GEAR CONTROL & POSITION INDICATOR
18. FLAP CONTROL
19. POWER LEVER COLLECTIVE CONTROL
20. POWER CONTROL
21. TACHOMETER
22. TORQUE
23. EXHAUST TEMPERATURE
24. EMERGENCY PANEL
25. FIRE EXTINGUISHER CONTROLS
26. LIGHTING, HEATING, DEFROSTING & MISC. PANEL
27. CIRCUIT BREAKER PANEL
28. CABIN INSULATION
29. RUDDER PEDALS

$$\begin{aligned}
 & \text{1. } \frac{1}{x^2} = x^{-2} \Rightarrow \frac{d}{dx} x^{-2} = -2x^{-3} = -\frac{2}{x^3} \\
 & \text{2. } \frac{d}{dx} \ln x = \frac{1}{x} \\
 & \text{3. } \frac{d}{dx} e^x = e^x \\
 & \text{4. } \frac{d}{dx} \sin x = \cos x \\
 & \text{5. } \frac{d}{dx} \cos x = -\sin x \\
 & \text{6. } \frac{d}{dx} \tan x = \sec^2 x \\
 & \text{7. } \frac{d}{dx} \cot x = -\csc^2 x \\
 & \text{8. } \frac{d}{dx} \sec x = \sec x \tan x \\
 & \text{9. } \frac{d}{dx} \csc x = -\csc x \cot x \\
 & \text{10. } \frac{d}{dx} \arcsin x = \frac{1}{\sqrt{1-x^2}} \\
 & \text{11. } \frac{d}{dx} \arccos x = -\frac{1}{\sqrt{1-x^2}} \\
 & \text{12. } \frac{d}{dx} \arctan x = \frac{1}{1+x^2} \\
 & \text{13. } \frac{d}{dx} \operatorname{arccot} x = -\frac{1}{1+x^2} \\
 & \text{14. } \frac{d}{dx} \operatorname{arcsec} x = \frac{1}{x\sqrt{1-x^2}} \\
 & \text{15. } \frac{d}{dx} \operatorname{arccsc} x = -\frac{1}{x\sqrt{1-x^2}}
 \end{aligned}$$
[illegible][illegible]

13

$$\begin{aligned} C(\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3, \mathbf{p}_4, \mathbf{p}_5, \mathbf{p}_6) &= \frac{1}{2} \left(\mathbf{p}_1 \mathbf{p}_2 \mathbf{p}_3 \mathbf{p}_4 \mathbf{p}_5 \mathbf{p}_6 \right) \\ &= \frac{1}{2} \left(\mathbf{p}_1 \mathbf{p}_2 \mathbf{p}_3 \mathbf{p}_4 \mathbf{p}_5 \mathbf{p}_6 \right) \\ &= \frac{1}{2} \left(\mathbf{p}_1 \mathbf{p}_2 \mathbf{p}_3 \mathbf{p}_4 \mathbf{p}_5 \mathbf{p}_6 \right) \\ &= \frac{1}{2} \left(\mathbf{p}_1 \mathbf{p}_2 \mathbf{p}_3 \mathbf{p}_4 \mathbf{p}_5 \mathbf{p}_6 \right) \end{aligned}$$

1. 在“开始”菜单中，单击“运行”，输入以下命令：
 $\text{cd } \backslash \text{Program Files} \setminus \text{Internet Explorer} \setminus \text{IEXPLORE.EXE}$
 按回车键。



RUDDER ANTENNA DOME

NOSE GEAR AUXILIARY LANDING PAD
(FORWARD FLIGHT LANDING POSITION)

NOSE GEAR AUXILIARY LANDING PAD
(VERTICAL FLIGHT LANDING POSITION - UNPREPARED SURFACES)

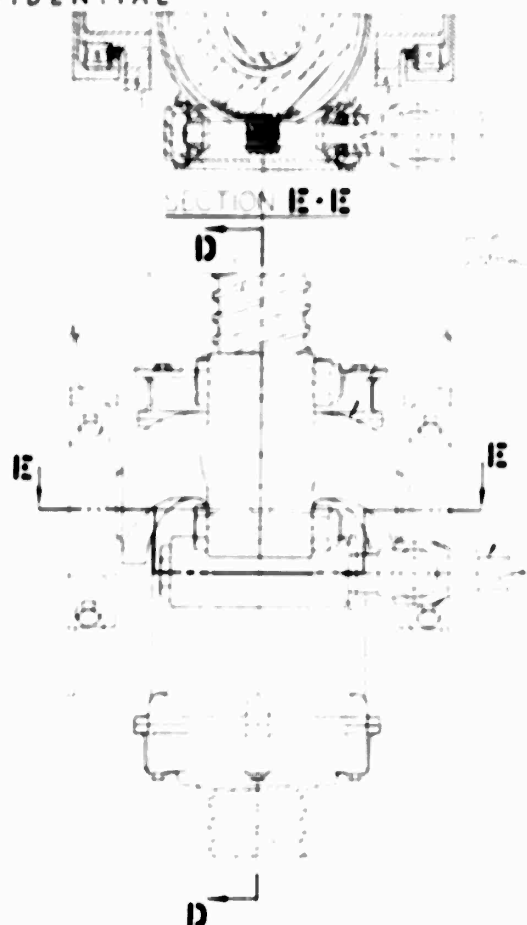
EMERGENCY ESCAPE TUBE

WHEELS
CARGO COMPARTMENT DECK

MAIN LANDING GEAR RETRACTED POSITION
MAIN LANDING GEAR AUXILIARY LANDING PAD
(FORWARD FLIGHT LANDING POSITION)
MAIN LANDING GEAR AUXILIARY LANDING PAD
(VERTICAL FLIGHT LANDING POSITION - UNPREPARED)

SECTION 13-13

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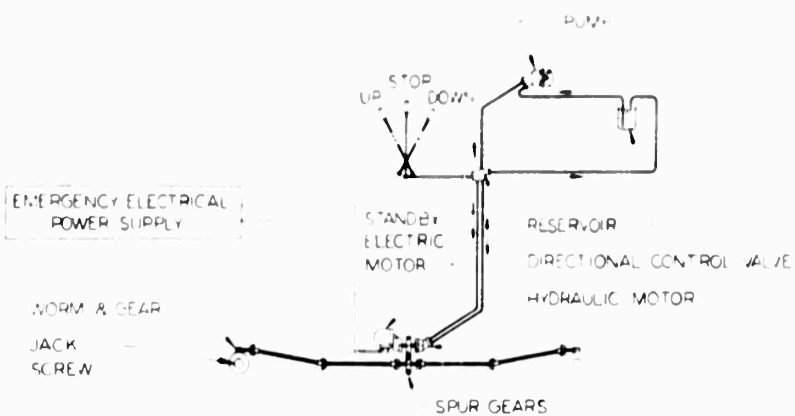
SECTION 13-13

SECTION 12-12

SCALE: 1" = 1'-0"

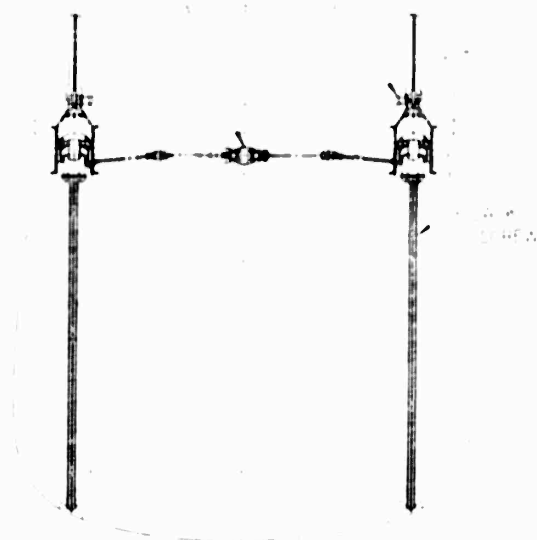


SECTION 10-10

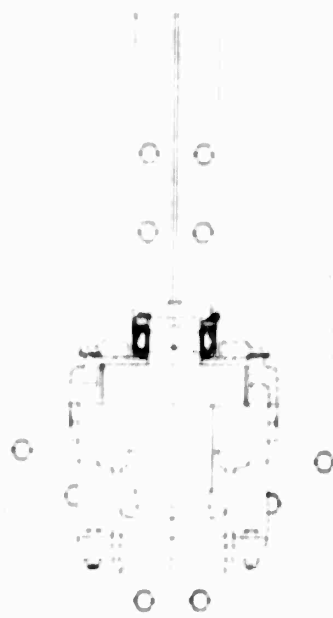


JACK ACTUATOR SYSTEM

(SCHEMATIC)
SCALE - NONE



VIEW A-A

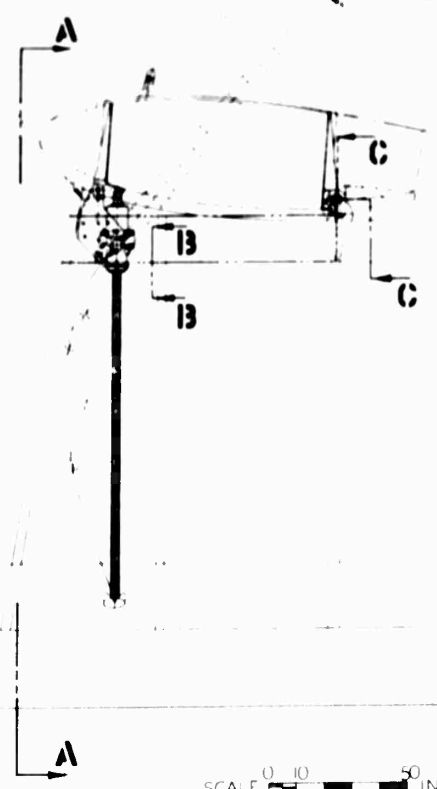


1. This drawing is a top view of the wing hinge assembly. It shows the main hinge structure and the attachment points for the wing. The drawing is a technical illustration and should be used as a guide for assembly.



WING
SECTION C-C
SCALE 0 10 50 INCHES

WING AND SUPPORT



SCALE 0 10 50 INCHES
EXCEPT AS NOTED

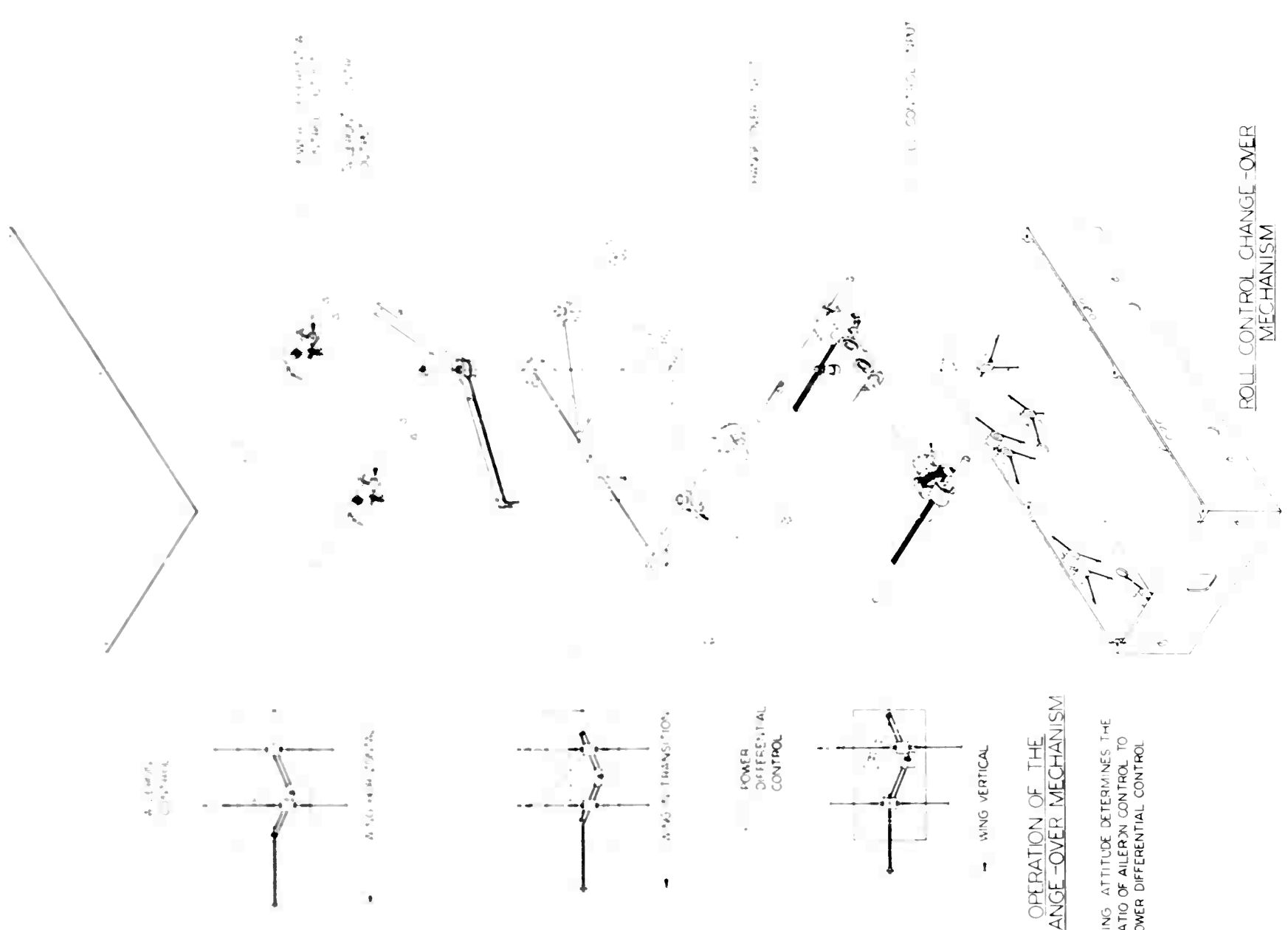
Hiller Helicopters
PALO ALTO, CALIFORNIA

WING HINGE AND ACTUATOR SYSTEM

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SCALE NOTED	DRAWN G. LARSON	DATE 3/12/56	DRAWING NO. 1048A-003
APPROVED		DATE	

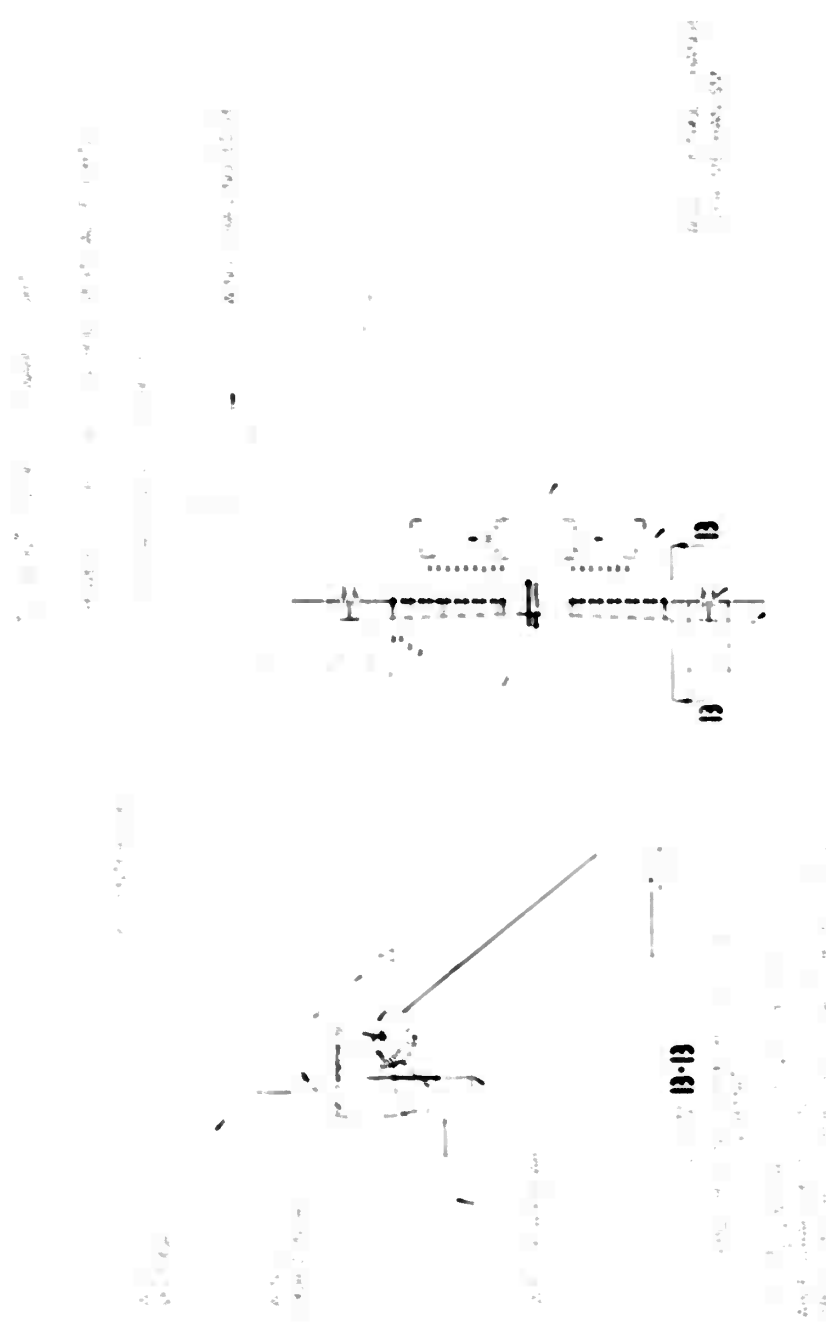
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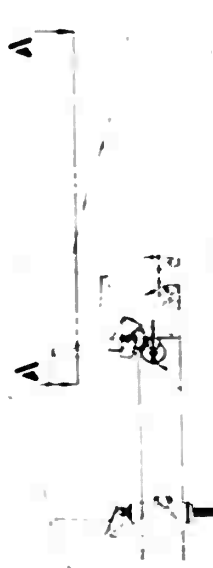
OPERATION OF THE
CHANGE-OVER MECHANISM

WING ATTITUDE DETERMINES THE
RATIO OF AILERON CONTROL TO
POWER DIFFERENTIAL CONTROL

ROLL CONTROL CHANGE-OVER
MECHANISM



A-A



WING ATTITUDE DETERMINES THE RATIO
OF AILERON CONTROL TO POWER
DIFFERENTIAL CONTROL, AND
MAY BE ADJUSTED TO MEET REQUIREMENTS.

HINGE CENTERLINE

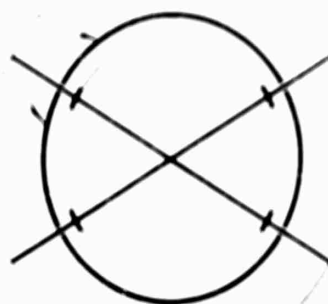
ALTERNATE METHOD
CABLE ROUTING THROUGH THE HINGE
A SHORT LENGTH OF CABLE IS ROUTED ALONG
THE HINGE CENTERLINE AND TWISTS WHEN
WING ATTITUDE IS CHANGED.

Miller Helicopters
PALO ALTO, CALIFORNIA

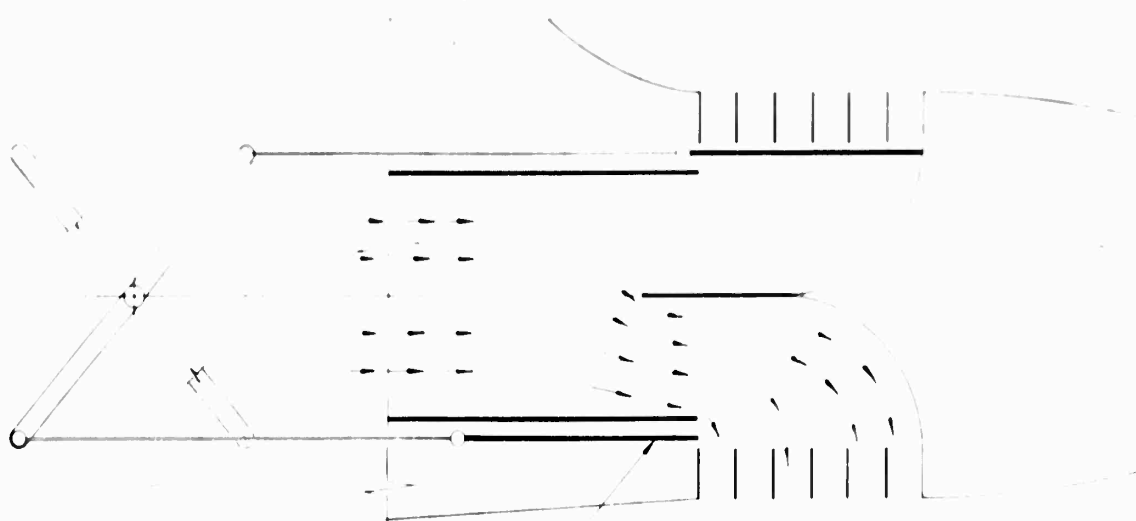
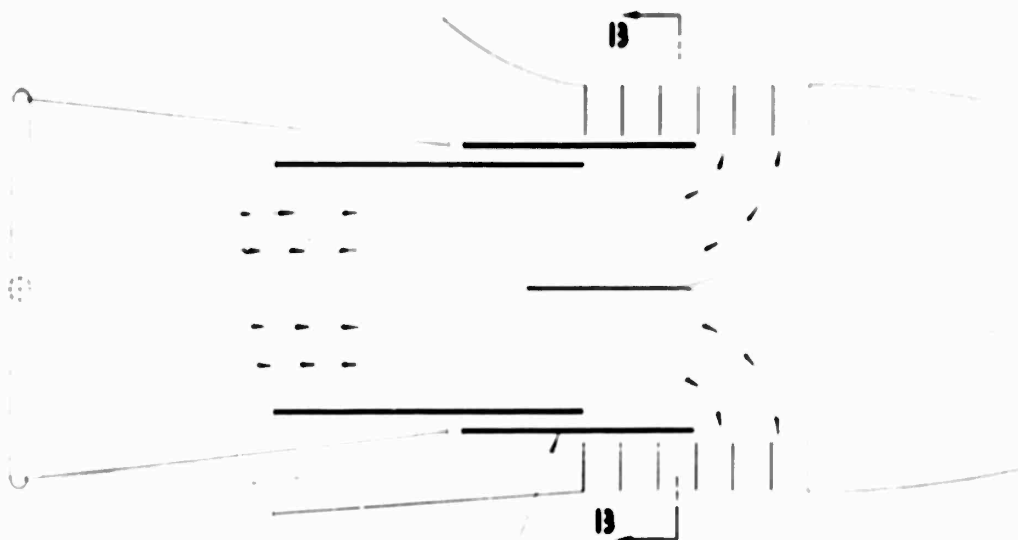
ROLL CONTROL SYSTEM

SCALE	DRAWING LARSON	DATE 3/24/58	DRAWING NO.
NOTED	APPROVED	DATE 4-1-58	1048A-004

CONFIDENTIAL



13-13



SLIDE VALVES IN POSITION FOR MAXIMUM
FORWARD PITCHING MOMENT

(YAW CONTROLS ARE SIMILAR TO PITCH CONTROLS)

CONTROL MECHANISM
SCHEMATIC

PITCHING
NUMBER 8

3/4 VIEW OF PITCHING NUMBER 8

A-A

1/4 VIEW OF PITCHING

PORTABLE HOIST FOR RAISING
AND LOWERING ENGINES

INTEGRAL LADDER ON
DOOR PROVIDES EASY
ACCESS TO ENGINES

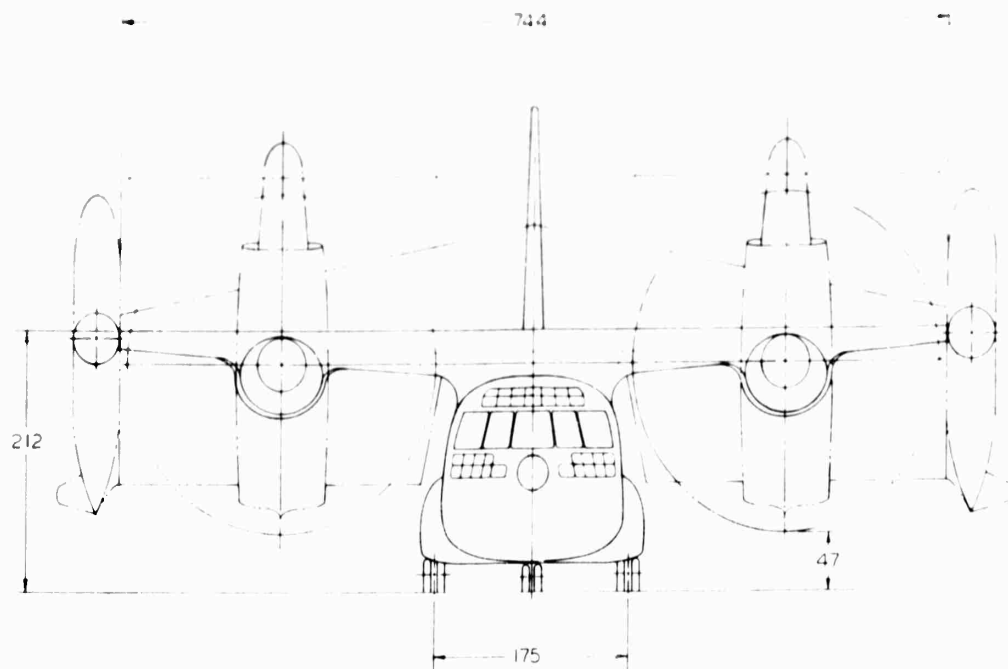
SCALE 0 10 50 INCHES

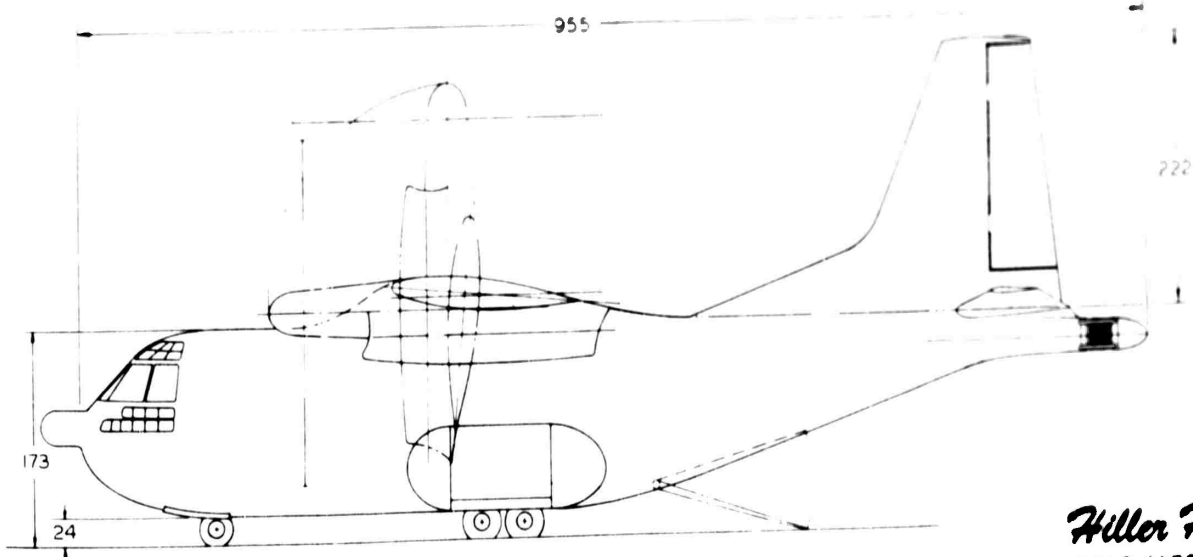
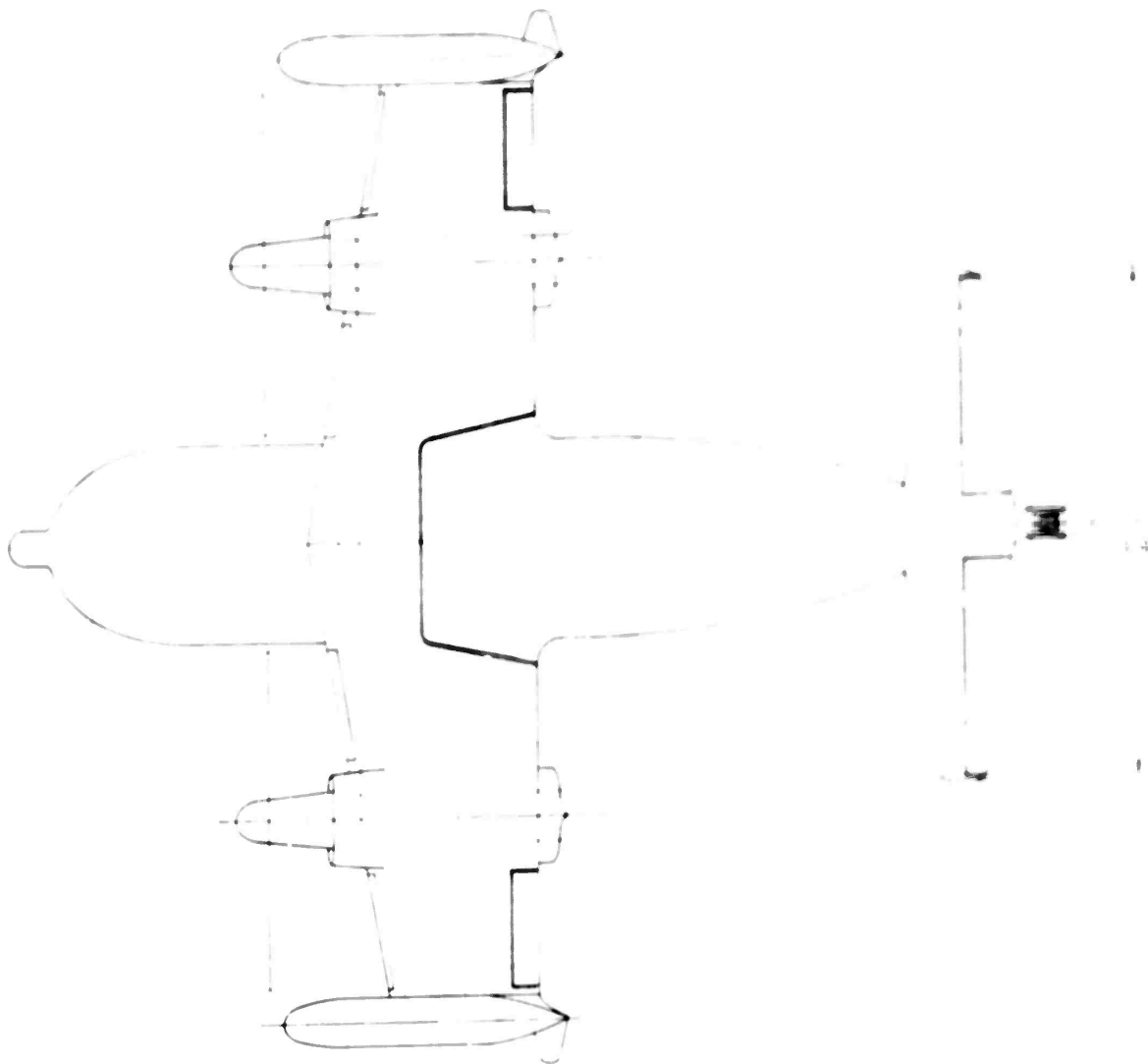
Hiller Helicopters
PALO ALTO, CALIFORNIA

CONFIDENTIAL

PITCH AND YAW AUXILIARY UNIT			
SCALE	DRAWN L. TILTON	DATE 3-23-56	DRAWING NO.
NOTED	APP'D	DATE	10-18-56

CONFIDENTIAL





SCALE 0 50 100 200 INCHES

CONFIDENTIAL

Hiller Helicopters
PALO ALTO, CALIFORNIA

GENERAL ARRANGEMENT		PROPELLOR		AIRCRAFT	
MODEL 1048 C		DATE		DRAWN BY	
SCALE NOTED	DRAWN LITTLETON	DATE	1048C	3 NO.	00
APPROVED	DATE				