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INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS

CELESTIAL NAVIGATION TRAINER

AN-2554-1

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TABLE OF CONTENTS

ILLUSTRATIONS

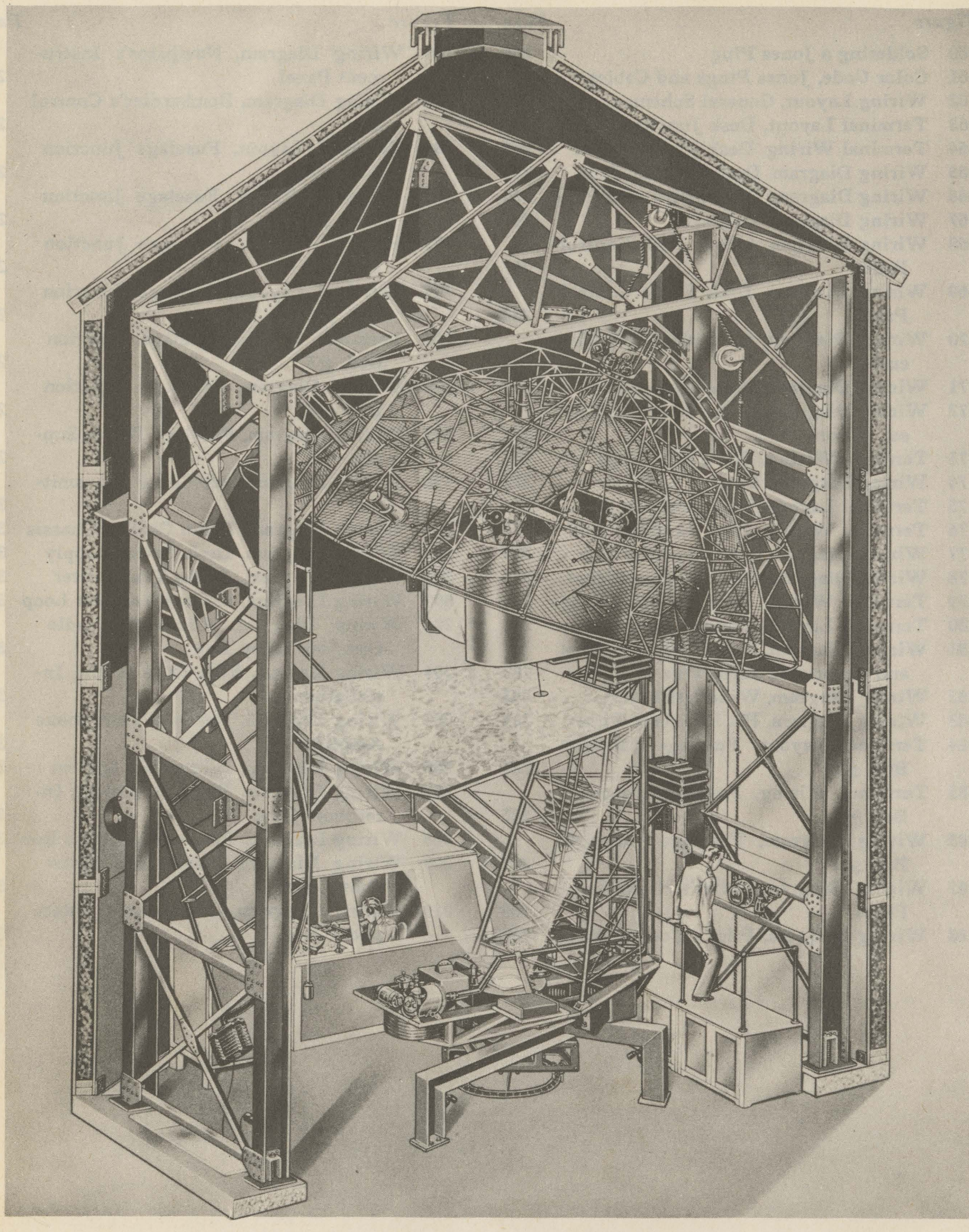

Figure 1—Celestial Navigation Trainer

SECTION I
INTRODUCTION

1. This publication has been prepared as the basic Handbook on the AN-2554-1 Celestial Navigation Trainer manufactured by Link Aviation Devices, Inc., Binghamton, New York. It contains a general and detailed description of the Trainer, together with instructions for its installation, operation, inspection and maintenance.

2. The AN-2554-1 Celestial Navigation Trainer (Link) is a synthetic ground training device which provides a navigator, bombardier, radio operator, and pilot with working conditions similar to those in the air. This Trainer is used to develop crew coordination, and also as a training device for navigators, bombardiers, pilots and radio operators.

3. Night flight using celestial navigation may be simulated for any time and longitude at latitudes ranging from 35° N to 85° N. Flight on instruments (not using celestial navigation) may be simulated for any time, longitude or latitude. Contact and bombing flights may be simulated over any terrain for which projection plates are provided.

SECTION II
GENERAL DESCRIPTION

1. PURPOSE OF THE TRAINER.

The AN-2554-1 Trainer (figure 1) is a synthetic training device making available to pilots, navigators, bombardiers, and radio operators simulated flying conditions in daylight, darkness, or both in sequence, depending upon the type and length of problem that is to be used.

2. MAIN ASSEMBLIES.

a. GENERAL.—There are six main assemblies contained in the Trainer; they are the celestial mechanism, the fuselage, the tower and counterbalance frame, the base, the terrain mechanism, and the control desk.

b. THE CELESTIAL MECHANISM.—This mechanism is supported by triangular trusses forming an arch with two main support columns resting on a concrete base. (See figure 1.) Attached to the triangular trusses and to the north (north in the Trainer is determined by the vertical plane of the dome rail) steel column are brackets which hold a curved dome rail. Running along the dome rail on rollers is a gear box to which is attached a celestial dome. The celestial dome is constructed of welded aluminum or steel ribs supporting a wire mesh covering. On the mesh are positioned pin point lamps of varying intensity representing stars of the major constellations and also miscellaneous stars. The celestial dome is a representation of the northern hemisphere and shows approximately 379 stars from 10° to 90° north declination. Twelve of the navigational stars are collimated and sights on them may be taken with a sextant from the navigator's station in the fuselage to obtain "fixes," thus establishing the location of the aircraft with respect to the surface of the earth. Star movement in time and space, and changes incurred by ground speed and direction are simulated by movement of the dome which in turn is controlled by various drives mounted on and contained within the dome gear box. There is one exception in that the latitude drive is located on the north steel column above the operator's platform. On the south steel column is located a counterweight in the form of a sector which balances the celestial dome in its travel along the dome rail. The movements of the dome may be controlled so that the position of the stars is always correct with respect to a known position on earth, or with respect to the position of the aircraft while in flight. Various controls and indicators are used to set the dome to any particular time, place and date, and to maintain correct movement of the dome relative to the Trainer.

c. FUSELAGE.

(1) The fuselage is attached to the tower by means of a universal joint and is located beneath the celestial dome. The fuselage is free to pitch, bank, and turn within the angular limits normal to

instrument flying. Attached to the tower directly below the fuselage is a screen upon which is projected the terrain image. The interior of the fuselage represents the interior of a bombing aircraft. It is built to carry a crew of four; the navigator, the radio operator, the pilot, and the bombardier. An instructor may replace one of the crew if desired. Equipment for navigation consists of an instrument panel, adjustable seat, collapsible table, map case, and two trays for navigator's equipment, as well as provision for attaching a drift indicator, bomb sight, astro compass, and astrograph. Equipment for piloting the Trainer includes the control column and wheel, rudder pedals, instrument panel, throttle, constant speed propeller controls, and switches for the landing gear and flap position indicating lights.

(2) The pilot's instrument panel divides the fuselage into two sections. The forward section contains the equipment for navigation and bombing, and the rear section is equipped for the pilot and radio operator. The radio equipment in the Trainer consists of a loop azimuth control, work table, and a collapsible seat. Adjacent to the pilot's seat is a collapsible seat which can be occupied by the instructor or bombardier. The bombardier must change seats with the navigator on approaching the bombing objective.

d. TOWER AND COUNTERBALANCE FRAME.

(1) These units are mounted on the base and are free to rotate around the main bearing. On the counterbalance frame is mounted the vacuum supply, wind drift mechanism, and other items necessary for the operation of the Trainer. The tower is mounted on the rear section of the frame and can be adjusted by shimming or shifting the legs slightly on the counterbalance frame. Large weights are attached to the front section of the frame for balancing the fuselage and tower, and to prevent binding or misalignment of the tower and frame on the main bearing.

(2) Included as part of this assembly is the instrument drive take-off mounted on the top rim of the main bearing housing. This take-off is the terminal for the Trainer heading drive and the loop azimuth drive motor which is controlled by the radio receiver.

(3) The turning motors are located on the rear section of the counterbalance frame and by means of a system of pulleys and belts passing around the main bearing, rotate the counterbalance frame and tower. This rotation is actuated by vacuum applied in the fuselage by means of the rudder control through the rudder valve to the turning motors.

e. TRAINER BASE.—The base is a three-legged welded steel support upon which rests the main bearing, tower and counterbalance frame, and the fuselage. The base is secured to the floor of the Trainer building by means of bolts on each leg and can be leveled by the use of three leveling screws which bear against the building floor through the tapped holes in each leg. Supported in the triangular section of the base is a main bearing upon which the tower and fuselage, and the counterbalance frame, rotate. In the center of this bearing is an adjustable lens through which the terrain image is projected upward to the projection screen.

f. TERRAIN MECHANISM.

(1) The terrain mechanism lies directly beneath the base and is mounted on a circular azimuth rail which is bolted to the floor by lag screws. The azimuth rail can be leveled by means of leveling screws which pass through tapped holes and bear against the building floor. In the center of the azimuth rail, mounted on the terrain base frame, is located the terrain projector which houses a series of reflecting mirrors and condensing lenses.

(2) The whole assembly is positioned accurately beneath the center of rotation of the celestial dome. Riding the azimuth rail on four rollers is the terrain base frame which holds the plate carriage and a piece of plate glass 20 inches by 33 inches which forms the base for a diapositive print of the terrain to be projected. The terrain base frame and plate carriage can be positioned according to any particular plate setting so that true north of the terrain image agrees with true north of the celestial dome. The projection plate represents an area of approximately 57 statute miles in width by 104 statute miles in length as seen from an altitude of 10,000 feet (± 100 feet) above terrain.

(3) The terrain base frame has two rails, one at either end, and the projection plate carriage mounted on rollers is free to move back and forth along these rails. The plate itself is free to move back and forth on rollers attached to the sides of the carriage. These two movements are at right angles to one another and permit horizontal movement in any direction in the plane of the plate.

(4) The projection plate drive consists of two track teletorques which transmit track azimuth to the drive wheel assembly. This assembly consists of two receiver teletorques with rubber drive wheels which engage the projection plate, and transmit ground speed to the plate. The housings of these ground speed drive receiver teletorques are connected to the track teletorques by a spindle and gear train.

g. OPERATOR'S CONTROL DESK.

(1) The control desk is located in a lightproof booth on the floor of the Trainer building. It is the distribution center for the power supply to all parts of the Trainer. The desk contains the controls and indicators necessary for the operation of the celestial dome, terrain mechanism, clouds, and for operation of the radio for any type of navigation problem.

(2) In the upper left-hand drawer (the dome control panel) of the desk are located the switches and variacs controlling the movements of the celestial dome.

(3) In the lower left-hand drawer (the projection control panel) are switches and variacs controlling the intensity of star, cloud, and ground illumination. This drawer also provides filing space for correspondence, charts, or records pertaining to the operation of the Trainer.

(4) In the center drawer of the desk is located the radio equipment of the Trainer. It is possible by use of this equipment to simulate actual radio range practice with a choice of five ranges, any two of which may be used simultaneously. In addition, direction finding, "Fan," "M," and "Z" type markers, control tower communication, external interference, interphone communication, and instrument landings may be simulated.

(5) In the upper right-hand drawer, space is provided for storing microphones and headsets, and in the lower right-hand drawer, space for storing the recorder when not in use.

(6) Graticules of any geographical section to be used in a particular problem are attached to the surface of the desk.

(7) An automatic recorder provided with an inking wheel is driven over the surface of the graticule, thus tracing a permanent record of the actual track of the Trainer during a problem.

(8) On an instrument panel located above the surface of the desk is mounted a group of indicators showing latitude, longitude, the LHA Aries and time. The indicators are used as a guide in manipulating the controls in the desk drawers to synchronize the dome with the Trainer position as indicated by the recorder.

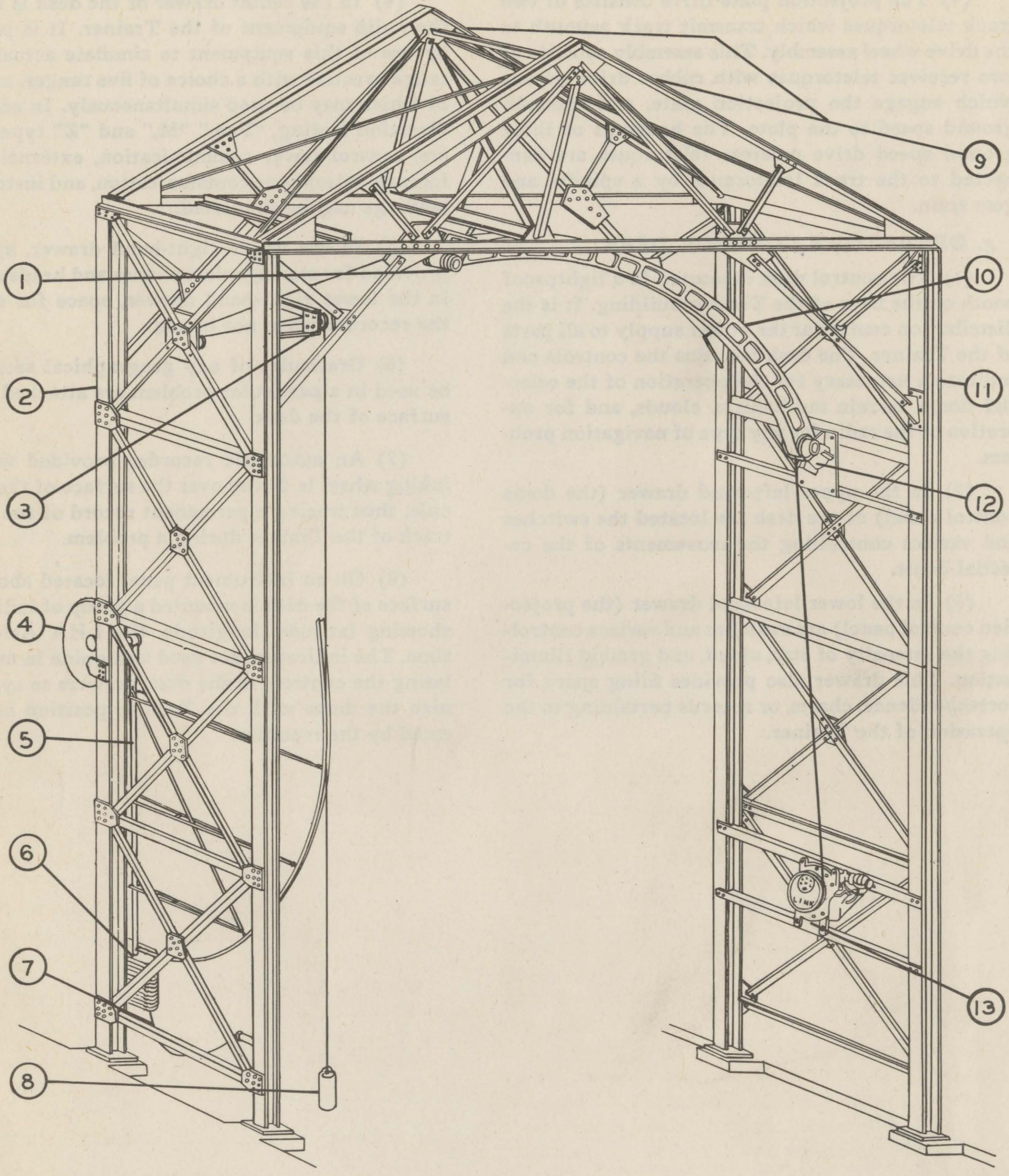

Figure 2—Main Structure

1. *South Dome Rail Bracket*
2. *South Tower Column*
3. *Guide Pulley*
4. *Sector Counterweight*
5. *Dome Counterweight Sector*
6. *Dome Counterweight*
7. *Dome Snubber*
8. *Dome Return Weight*
9. *Triangular Trusses*
10. *Dome Rail*
11. *North Tower Column*
12. *North Dome Rail Bracket*
13. *Latitude Reset and Drive*

SECTION III
DETAILED DESCRIPTION

1. CELESTIAL MECHANISM.

a. INTRODUCTION.

(1) The celestial navigation mechanism provides a simulation of the northern celestial hemisphere with the accuracy necessary to practice celestial navigation. Sitting in the navigator's compartment, the navigator is able, under varying conditions of visibility, to select stars and take observations on them in the normal manner. The complete flight is recorded so that both the student and instructor can check the work after the problem has been flown.

(2) The northern hemisphere is represented by a section of a spherical dome with star lamps mounted on it. The outstanding constellations of the northern hemisphere, together with about 288 other stars varying from the first to the fifth magnitude, are represented. Observations may be taken upon twelve of the prominent "navigational" stars ordinarily used in practice.

(3) The dome is mounted so that it is capable of the movements required to simulate celestial conditions as existing for an observer traveling anywhere in northern latitudes between 35° N and 86° N. Thus, the movement of the dome is affected both by passage of "time" and change of observer's position in latitude and longitude.

(4) The celestial mechanism is supported on two upright columns spanned by two triangular trusses. Two brackets within this structure support the celestial dome rail. The hub of the dome is fixed to the shaft of the dome gear box, which is mounted upon the celestial dome rail. The dome receives its rotary motion from the main shaft of the gear box. To vary the angle of the dome shaft with the vertical, and thus simulate latitude change, the gear box can be driven up or down the rail by the latitude drive.

(5) The celestial dome is comprised of seventeen tubular ribs reinforced with circular hoops to which wire netting is attached. Small lamps mounted on the wire mesh represent approximately 126 stars of the first to the third magnitude and the 241 stars from the third up to the fifth magnitude. These stars provide a likeness of the northern hemisphere under varying conditions of visibility. The impression of clear or limited visibility is simulated by lighting different groups of stars, or by controlling their intensity with a variac.

(6) Twelve of these stars are collimated in order that observations may be taken on them with a sextant. The essential quality of the collimator, as utilized here, is that it emits parallel rays of light contained within a 5-inch cylinder.

(7) In addition to the stars already described, twelve "recognition" stars are provided. They are small lamps similar to those used for stars of the first to the third magnitude. They are mounted at one side of the collimators (the light from these stars is reflected from a prism at the center of the collimator lens) and serve two purposes; first, to identify the collimated navigation stars preparatory to taking observations, and second, to fill in the blank space left in a constellation when the navigator is not sitting with his eye within the 5-inch cylinder of light rays from a collimator.

b. THE MAIN STRUCTURE. (*See figure* 2.)

(1) DESCRIPTION.—The main structure is a steel arch made in six sections. Each unit is made of two similar sections, bolted together one above the other, to form a single column. The top of the arch is formed by two triangular trusses lying parallel and joining the two uprights together. The trusses are reinforced by cross bracing. The peak of the arch is approximately forty feet above the floor of the Trainer building. In order to insulate the structure from any ground vibrations which would tend to disturb its adjustments, it is mounted on concrete piers insulated from the floor of the building. For the same reason the structure does not touch the Trainer building at any point.

(2) DOME COUNTERWEIGHT.

(*a*) The dome counterweight consists of a sector framework pivoted at the center with weights attached to the lower end of its outer circumference. A flexible cable is led from the weights around the outer edge of the sector up to the dome gear box on the dome rail. When the gear box is

at the top of the rail (the pole star directly overhead) no counterweight is necessary since all the weight of the dome is taken by the rail. As the dome moves down the rail its weight is transferred at a steady rate to the cable which connects with the sector rim. In order that the counterweight may take up the weight of the dome at this same rate, the sector moves in an arc of a radius equal to the radius of the dome rail. The dome is reset along the rail by operating a hand crank on the latitude control panel, mounted on the north column of the main structure. This crank is geared to a drum from which a cable runs to the nearest end of the gear box. The dome may be drawn down the rail by winding in the cable.

(*b*) A second weight is provided to return the dome to the top of the rail. This is an auxiliary weight which hangs beside the sector structure on a separate cable. If the hand crank is allowed to free-wheel, the dome runs up to the top of the rail of its own accord. A second function of the auxiliary weight is to keep the cable under sufficient tension to hold the dome gear box safety catches in the disengaged position. [See section III, par. 1*d*(6).]

(*c*) A third and last set of weights serves to counterbalance the weight of the sector structure itself. These weights are near the counterweight sector pivot on an extension of the top horizontal sector member. They are adjusted so that they produce a torque equal and opposite to that of the sector frame around the pivot point.

c. CELESTIAL DOME RAIL. (*See figure* 3.)

(1) DESCRIPTION.—The celestial dome rail is cast of nickel iron alloy. Its outer radius is 11 feet 2.6 inches; therefore, 10 degrees on the cir-

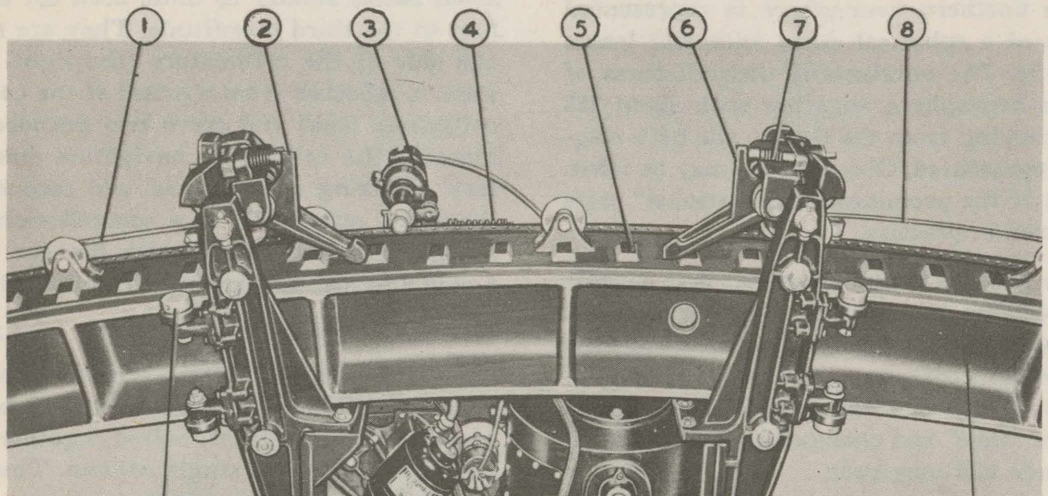

Figure 3—Celestial Dome Rail with Dome Gear Box

1. *Cable to Dome Counterweight*
2. *Safety Pawl*
3. *Latitude Teletorque*
4. *Connector Block*
5. *Safety Pawl Latch Lugs*
6. *Safety Pawl*
7. *Safety Pawl Spring*
8. *Cable to Latitude Drive Motor*
9. *Adjustable Positioning Rollers*
10. *Time Motor*
11. *Clutch Reset Motor*
12. *Dome Reset Motor*
13. *Dome Rail*

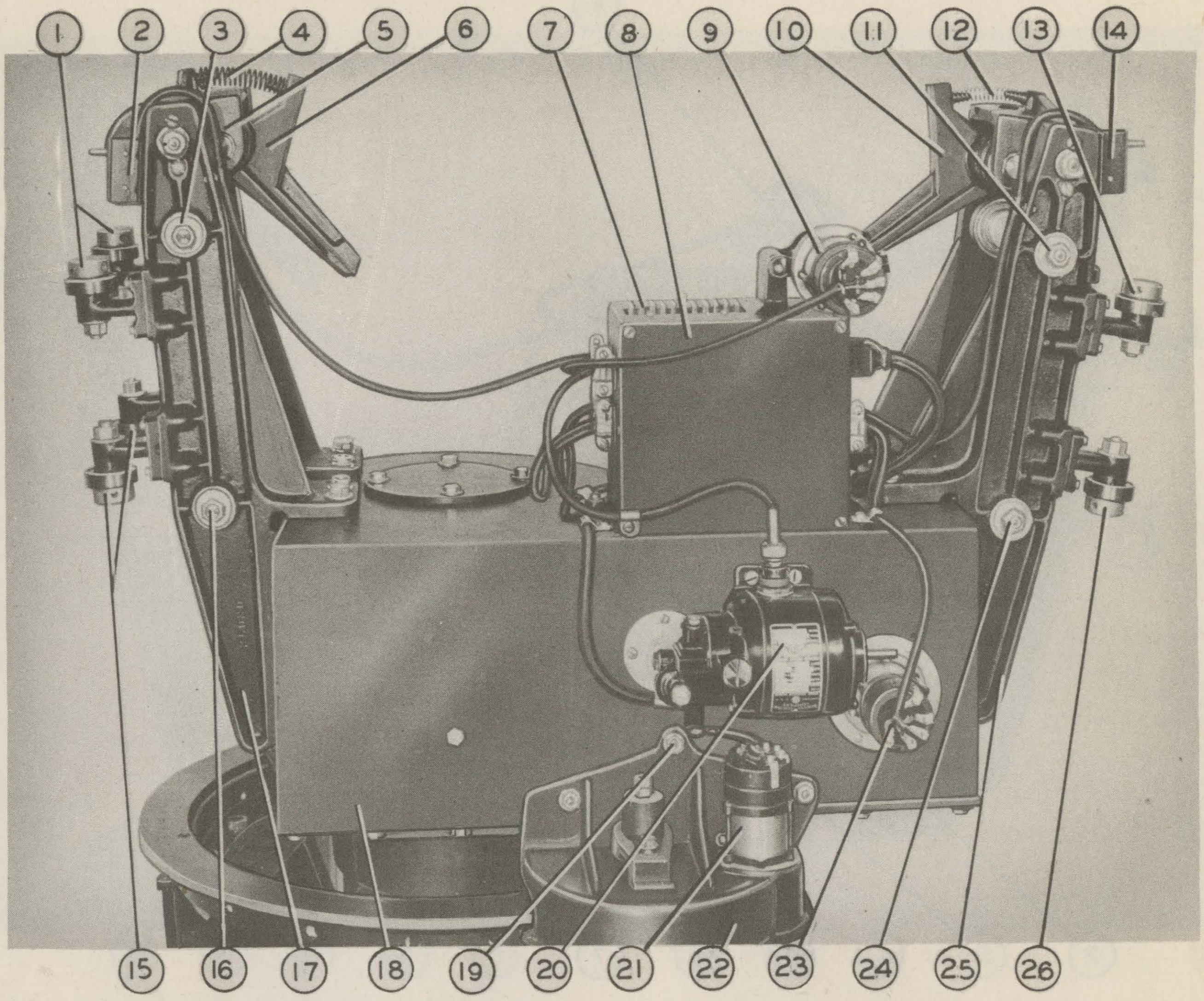

Figure 4—Dome Gear Box—West Side View

1. *Gear Box Rollers, North Side Upper*
2. *Micro-switch*
3. *Gear Box Rollers, North Top*
4. *Dome Safety Pawl Spring*
5. *Pawl Assembly*
6. *Dome Safety Pawl*
7. *Jones Plug Connector*
8. *Dome Junction Box*
9. *Latitude Drive Teletorque*
10. *Dome Safety Pawl*
11. *Gear Box Rollers, South Top*
12. *Safety Pawl Spring*
13. *Gear Box Rollers, South Side Upper*
14. *Micro-switch*
15. *Gear Box Rollers, North Side Lower*
16. *Gear Box Rollers, North Bottom*
17. *Gear Box Frame*
18. *Gear Box*
19. *LHA Take-Off Gear Adj. Mount*
20. *Longitude Motor*
21. *LHA Transmitter Teletorque*
22. *Gear Box Assembly—LHA*
23. *Time Transmitter Teletorque*
24. *Gear Box Roller, South Bottom*
25. *Gear Box Frame*
26. *Gear Box Roller, South Side Lower*

cumference equals 23.5 inches. Runways are machined along all four edges of the rail for the four pairs of rollers mounted on the gear box legs. The upper surface carries a series of small lugs which serve as stops for the dome safety catches. There are also other lugs spaced at 5-degree intervals carrying cable rollers that serve to guide the counterbalance and latitude drive cables when the dome moves up or down.

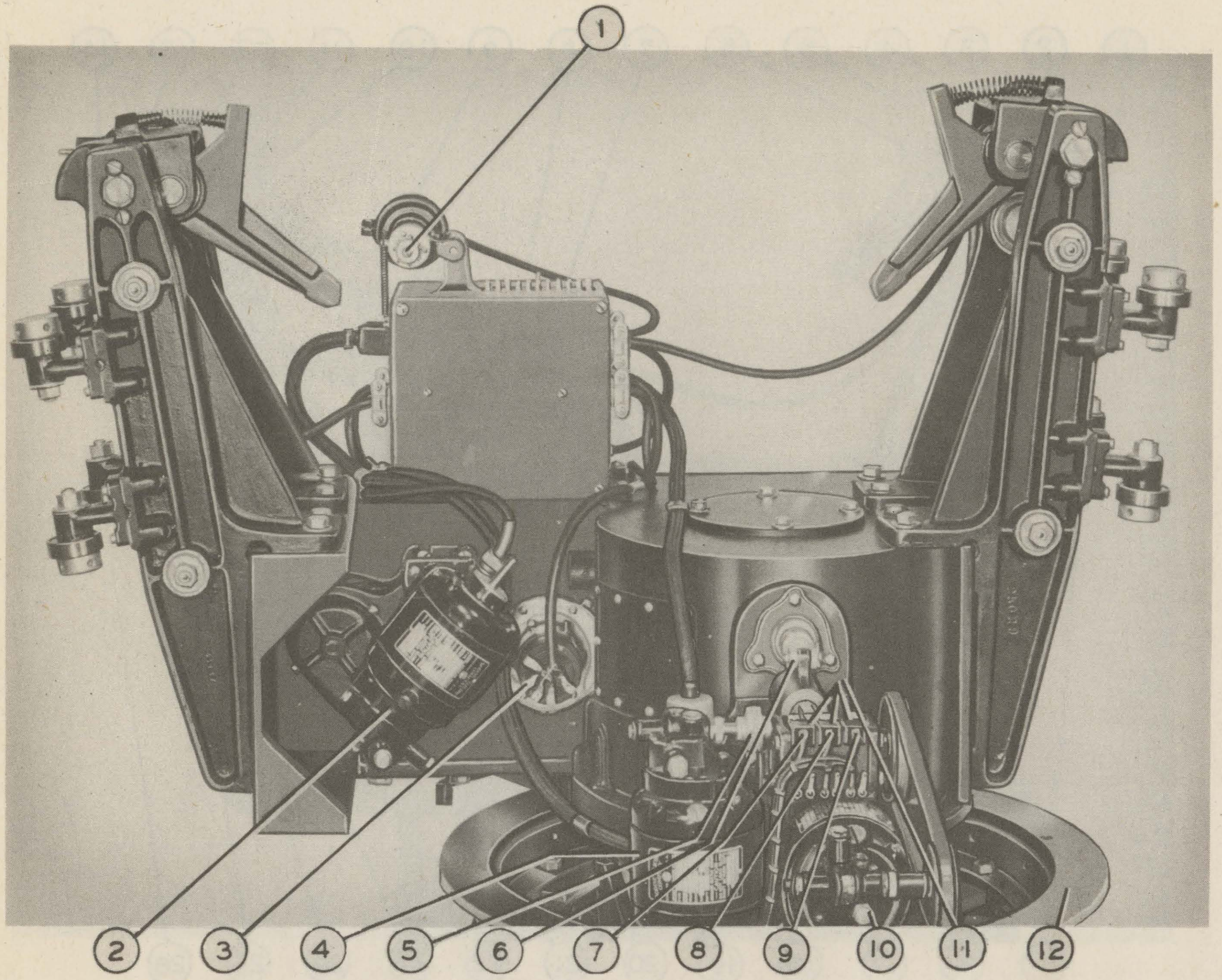

Figure 5—Dome Gear Box—East Side View

1. *Latitude Take-Off*
2. *Time Motor*
3. *Longitude Transmitter Teletorque*
4. *Clutch Motor*
5. *Clutch Motor Coupling*
6. *Clutch Actuating Plunger*
7. *Reset Motor*
8. *Reset Micro-switch*
9. *Neutral Micro-switch*
10. *Normal Micro-switch*
11. *Micro-switch Operating Cams*
12. *Dome Hub*

(2) DOME RAIL SUPPORT.—The celestial dome rail is supported by two brackets mounted within the main structure. The bracket holding the lower end of the rail is mounted on the north column. The bracket holding the upper end of the rail is mounted midway on a cross beam between the two triangular trusses. The brackets are U-shaped and the ends of the rail are fastened between the forks of these brackets by large pins. In order to permit alignment of the rail when it is installed, the brackets are adjustable. The bracket on the north column slides along the axis of the chord of the rail and rotates about the chord as an axis. The upper bracket on the cross beam is adjustable in a plane at right angles to the chord of the rail.

d. DOME GEAR BOX. (*See figures* 4 *and* 5.)

(1) MOVEMENTS OF THE DOME.

(*a*) The dome gear box is the center at which the various movements controlled at the desk are derived and transmitted to the dome. In order that celestial conditions existing for an observer traveling in any direction above the earth's surface may

be simulated, the dome is capable of two movements; first, movement along the arc of the rail to provide for change in latitude, and second, rotation about the hub to provide for changes in the LHA Aries because of changes in time and longitude.

(*b*) The dome is in all cases given a movement corresponding to the apparent motion of the stars. When an observer moves from the north pole toward the equator, the pole star appears to move from overhead toward the horizon. Exactly the same effect is seen by an observer standing in the navigator's compartment, while the dome is run from the top to the bottom of the dome rail. When the gear box is at the top of the rail, the dome (with the pole star approximately at its center) hangs directly overhead, while the celestial equator coincides with the observer's horizon. As the dome is run down the rail, it appears to the observer that he is traveling toward lower latitudes.

(*c*) The rotation of the dome provides for two entirely separate movements: first, rotation of the earth, and second, the observer's change of longitude. When the observer is stationary, he sees the stars rotating about the celestial pole at a rate corresponding to sidereal time. If the rate of rotation of the stars appears to vary from the rate due to sidereal time, the observer knows that he is traveling over the earth's surface (change of longitude). The apparent rate of rotation of the stars increases

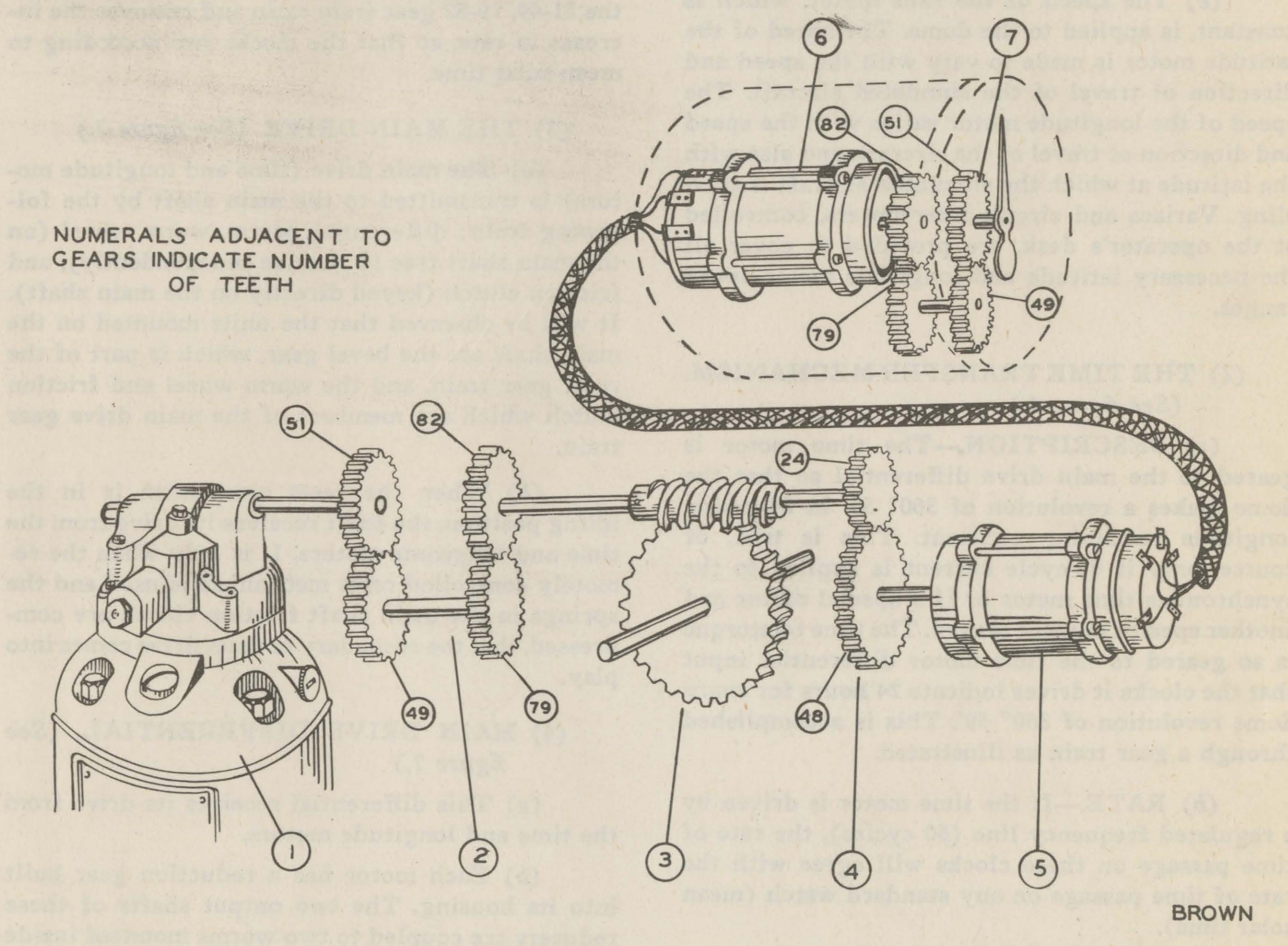

Figure 6—Time Transfer Mechanism

1. ***Time Drive Motor (Synchronous 2 rpm), Driving Dome and Clocks***
2. ***Gear Train Converting Mean Time Rate into Sidereal Time Rate***
3. ***Worm and Worm Wheel Rotate Dome***
4. ***Gears Driving Master Time Teletorque***
5. ***Master Time Teletorque***
6. ***Receiver Teletorque in "Clocks"***
7. ***Gear Train to Convert Sidereal Time Back to Mean Time***

when he travels eastward and decreases when he travels westward.

(*d*) These three dome movements are derived from three motors: the time motor (simulating rotation of the earth), the longitude motor (simulating change of longitude), and the latitude motor (simulating change of latitude). The time and the longitude drives are coordinated through a differential gear train in the dome gear box. If the observer is moving eastward, the longitude motor acts with the time motor and accelerates the rotation of the dome. If the observer is moving westward, the longitude motor works against the time motor and the rotation of the dome is retarded.

(*e*) The speed of the time motor, which is constant, is applied to the dome. The speed of the latitude motor is made to vary with the speed and direction of travel of the simulated aircraft. The speed of the longitude motor varies with the speed and direction of travel of the aircraft, and also with the latitude at which the simulated aircraft is traveling. Variacs and circuit interrupters, controlled at the operator's desk, are provided to cover all the necessary latitude and longitude motor speed ranges.

(2) THE TIME TRANSFER MECHANISM. (*See figure* 6.)

(*a*) DESCRIPTION.—The time motor is geared to the main drive differential so that the dome makes a revolution of 360° 59′ in 24 hours, longitude remaining constant. This is true, of course, only if 60-cycle current is applied to the synchronous time motor or if a special motor and another specific current is used. The time teletorque is so geared to the time motor differential input that the clocks it drives indicate 24 hours for every dome revolution of 360° 59′. This is accomplished through a gear train as illustrated.

(*b*) RATE.—If the time motor is driven by a regulated frequency line (60 cycles), the rate of time passage on these clocks will agree with the rate of time passage on any standard watch (mean solar time).

(*c*) UNITS OF THE TIME TRANSFER MECHANISM. (*See figure* 6.)

1. The time drive motor is a synchronous 2-rpm motor whose function is to drive the dome and clocks.

2. The function of the mean time to sidereal time gear train is to convert the mean solar time rate of the time drive motor to a sidereal rate of 360° 59′ of rotation per 24 hours of mean solar time.

3. The function of the worm and worm wheel (shaft to differential) is to rotate the dome.

4. The 1 to 2 ratio gears drive the master time teletorque.

5. The gear ratio converts the 2-rpm output shaft rotation of the time motor to 1 rpm at the master time teletorque (driven at a sidereal rate).

6. Receiver teletorques actuate "clocks" on the navigator's, pilot's, and operator's panels.

7. A gear train in the "clock" case reverses the 51-49, 79-82 gear train ratio and removes the increase in rate, so that the clocks run according to mean solar time.

(3) THE MAIN DRIVE. (*See figure* 7.)

(*a*) The main drive (time and longitude motors) is transmitted to the main shaft by the following train: differential, worm, worm wheel (on the main shaft free to revolve independently), and friction clutch (keyed directly on the main shaft). It will be observed that the units mounted on the main shaft are the bevel gear, which is part of the reset gear train, and the worm wheel and friction clutch which are members of the main drive gear train.

(*b*) When the reset mechanism is in the idling position, the shaft receives its drive from the time and longitude motors. It is only when the remotely controlled reset mechanism is used and the springs in the main shaft friction clutch are compressed, that the secondary or reset drive comes into play.

(4) MAIN DRIVE DIFFERENTIAL. (*See figure* 7.)

(*a*) This differential receives its drive from the time and longitude motors.

(*b*) Each motor has a reduction gear built into its housing. The two output shafts of these reducers are coupled to two worms mounted inside the gear box. The drive is transmitted through these worms to two worm wheels. The time worm wheel is shafted to the primary drive of the differential, and the longitude wheel bolted to the secondary, or spider drive. The output of the differential is transmitted through a coupling to the output worm

which drives the large worm wheel on the main shaft.

(5) THE MAIN SHAFT AND MAIN SHAFT DRIVES. (*See figure 7.*)

(*a*) The function of the main shaft is to transmit the movement of the main drive (time and longitude motors) and the secondary drive (reset motor) to the dome, one drive being disengaged while the other is in action.

(*b*) The two drives are made to operate by means of two cone friction clutches, one on the main shaft, and the other in the reset mechanism. These clutches are engaged alternately by the clutch motor which is controlled electrically from the operator's desk by a three-position rotary switch. These positions are labeled: "Normal" (dome is being driven by the time and longitude motors), "Neutral" (both clutches disengaged), and "Reset" (clutch of dome reset motor engaged). When the operator turns the rotary switch from normal to reset, the cam shaft completes half its cycle, disengaging the main drive clutch and engaging the reset clutch so that the desired drive

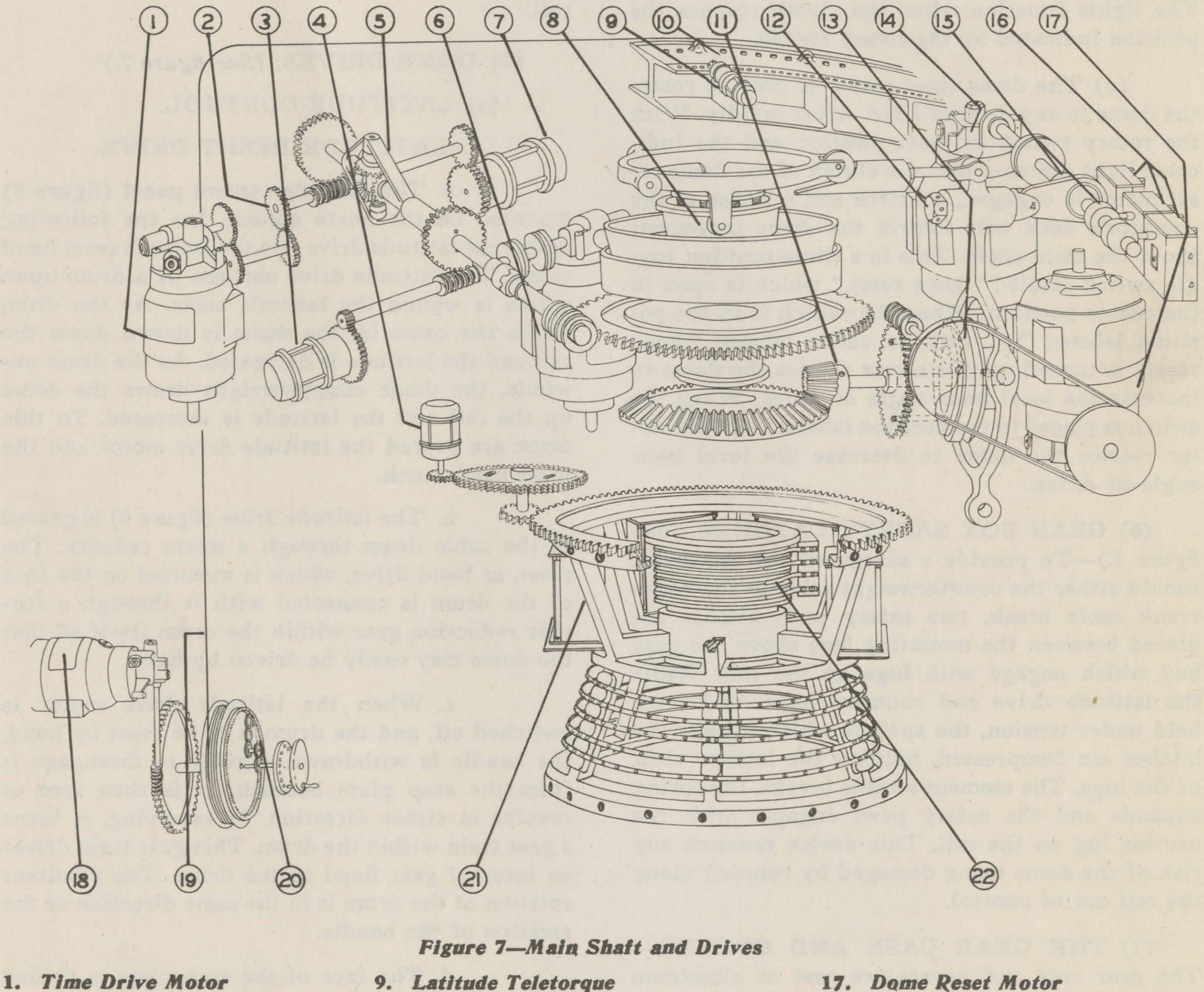

Figure 7—Main Shaft and Drives

1. ***Time Drive Motor***
2. ***Time Transfer Mechanism***
3. ***Longitude Teletorque***
4. ***LHA Aries Teletorque***
5. ***Main Drive Differential***
6. ***Longitude Drive Motor***
7. ***Time Teletorque***
8. ***Main Shaft Clutch***
9. ***Latitude Teletorque***
10. ***Dome Rail***
11. ***Shear Pin***
12. ***Clutch Spring Tension Adjustment***
13. ***Dome Reset Clutch***
14. ***Clutch Motor***
15. ***Cams***
16. ***Micro-switches***
17. ***Dome Reset Motor***
18. ***Latitude Drive Motor***
19. ***Latitude Drive Cable***
20. ***Latitude and Reset Drives***
21. ***Dome Hub***
22. ***Dome Collector Ring Assembly***

may be employed; turning the rotary switch to neutral disengages both clutches so that the entire mechanism can "free-wheel." Three microswitches, actuated by cams, are provided: one to open the motor circuit automatically when the clutch of the dome reset motor is engaged and the main shaft clutch is disengaged; a second to open the motor circuit automatically when the main shaft clutch is engaged and the clutch of the reset motor is disengaged; and a third which automatically opens the motor circuit when both clutches are disengaged. Three indicator lights are provided, one for each position of the rotary switch. The lights function when the clutch reaches the position indicated by the rotary switch.

(c) The dome reset motor is used to rotate the dome to any desired LHA Aries rapidly. With the rotary switch in reset position and the indicator light showing that the clutch of the dome reset motor is engaged, a switch and a variac at the operator's desk will control the dome movement about the main shaft. This is a three-position toggle switch labeled "dome reset," which is open in the center position. When the switch is in the position labeled "+" and the variac labeled "dome reset" is turned up, the motor rotates the dome to increase the local hour angle of Aries. When the switch is placed in the position labelel "—," the motor rotates the dome to decrease the local hour angle of Aries.

(6) GEAR BOX SAFETY CATCHES. (*See figure* 3.)—To provide a safeguard for the dome, should either the counterweight cable or the handcrank cable break, two safety pawl latches are placed between the mounting legs above the gear box which engage with lugs on the rail. While the latitude drive and counterweight cables are held under tension, the springs which engage the latches are compressed, holding the latches clear of the lugs. The moment a cable breaks, the spring expands and the safety pawl engages with the nearest lug on the rail. This device removes any risk of the dome being damaged by running along the rail out of control.

(7) THE GEAR CASE AND COVERS.—The gear case and covers are cast of aluminum alloy. The oblong portion of the case houses the differential gear train; the circular portion houses the main shaft and main shaft drives. The two covers complete the gear case; the circular cover houses the lower of the two main shaft bearings.

(8) THE FOUR MOUNTING LEGS. (*See figures* 3, 4, *and* 5.)—The four mounting legs are bolted to the housing and held in alignment by dowel pins. A total of eight pairs of rollers are placed so as to roll on all four surfaces of the rail. When the dome is at the top of the rail (the pole star directly overhead) the weight is taken by the rollers above the rail. As the dome moves down the rail, part of the weight is supported by the rollers beneath the rail. The rollers at the sides serve to remove all side play. The rollers are mounted on an eccentric cam which may be rotated to adjust the setting of the gear box on the rail.

(9) DOME DRIVES. (*See figure* 7.)

(*a*) LATITUDE CONTROL.

1. LATITUDE RESET DRIVE.

a. The latitude control panel (figure 8) mounted on the north column has the following units: the latitude drive and the latitude reset hand crank. The latitude drive consists of a drum upon which is wound the latitude cable. As the drum winds the cable in, the dome is drawn down the rail and the latitude is decreased. As the drum unwinds, the dome counterweight draws the dome up the rail and the latitude is increased. To this drum are geared the latitude drive motor and the reset hand crank.

b. The latitude drive (figure 8) is geared to the cable drum through a worm reducer. The reset, or hand drive, which is mounted on the face of the drum is connected with it through a further reduction gear within the drum itself so that the dome may easily be driven by hand.

c. When the latitude drive motor is switched off, and the drum is to be reset by hand, the handle is withdrawn slightly to disengage it from the stop plate beneath. It is then free to revolve in either direction. In revolving, it turns a gear train within the drum. This gear train drives an internal gear fixed to the drum. The resultant rotation of the drum is in the same direction as the rotation of the handle.

d. The face of the stop plate is drilled with twenty-four holes placed at equal distances around the circumference. When the handle is released the handle pin, actuated by a spring, falls back into the next stop plate hole to come under it. The ratios of the various gear trains and the

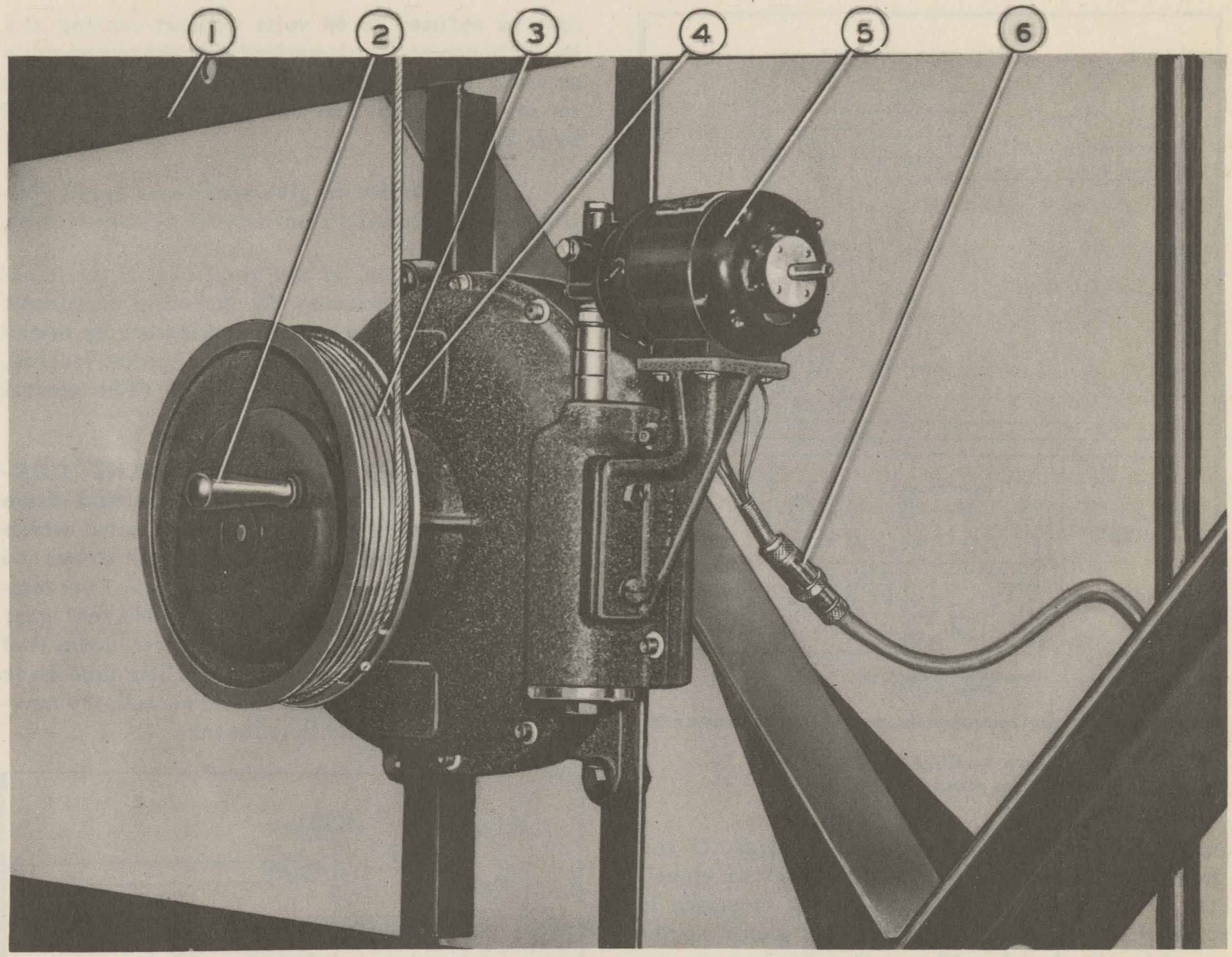

Figure 8—Latitude Drive and Reset Assembly

1. *Cross Member—North Column*
2. *Latitude Reset Handle*
3. *Cable Drum*
4. *Latitude Drive Cable*
5. *Latitude Drive Motor*
6. *Amphenol Connector*

resultant changes in latitude of the dome rail are as follows:

(1) Latitude drive reducer to drum—144 to 1.

(2) Reset handle to drum—10 to 1.

(3) One revolution of the drum equals 10 degrees of latitude on the rail.

(4) One revolution of the handle equals 1 degree on the rail.

(5) The holes on the stop plate, in terms of movement on the rail, are 2.5 minutes apart. Thus, the dome latitude may be set by hand to within 1.25 minutes of the desired setting. A more accurate setting is obtained by operating the latitude drive motor.

2. LATITUDE MOTOR AND CONTROLS. (*See figure* 9.)

a. The latitude motor is of the same type as the longitude motor and the same precautions should be observed in reducing speed by voltage control. [See section III, par. 1*d*(9)(b).]

b. The latitude motor control system is similar to that of the longitude motor except that it may be driven while the dome clutch is in operation. There are, however, two limit switches on the dome gear box which operate and open the latitude motor circuit if the gear box is driven to

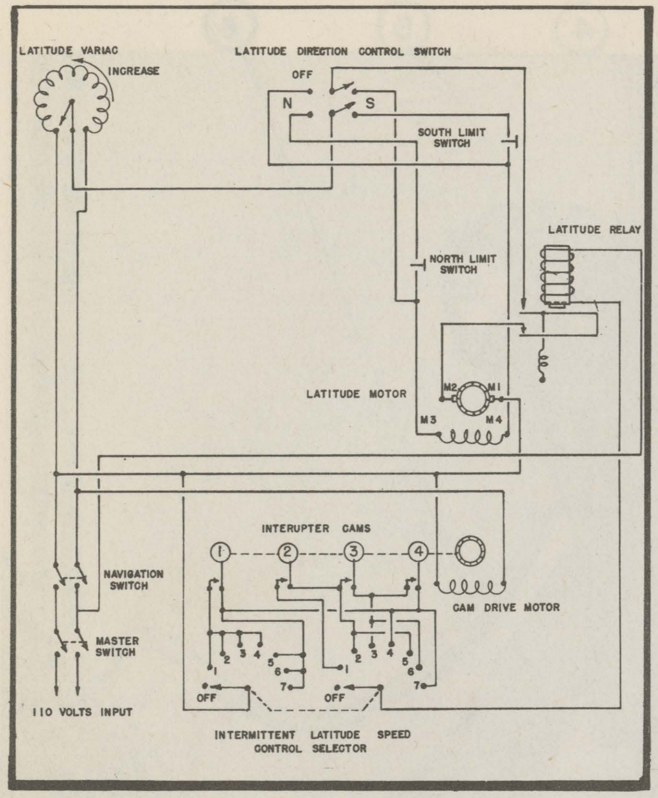

Figure 9—Wiring Diagram, Latitude Motor and Controls

either the north limit or the south limit. If the gear box is driven to the south limit of travel, the circuit driving the motor in that direction is opened but the circuit driving the motor northward is still closed and hence the gear box may be driven northward. The action is similar in case the gear box is driven to the north limit, except that north limit switch opens the north drive circuit and the gear box may only be driven southward. [See section III, par. 1*d*(9)(*b*).]

(*b*) LONGITUDE MOTOR AND CONTROLS. (*See figure* 10.)

1. The longitude motor is a series-wound reversible motor designed to operate on 115 volts at 60 cycles. Under normal load of 1/80 HP at 5000 rpm, this motor draws .4 amperes. There is a 900 to 1 gear ratio reducer on the output shaft of the motor. The speed of this motor may be varied within limits by varying the voltage. However, if the voltage is reduced to the point where the motor stalls, the motor windings are liable to be damaged due to abnormal current through the motor under this condition. As a general rule, the voltage may be reduced to 60 volts without causing any harm; however, if it is noticed that the motor stalls at some higher voltage a higher figure should be set as a minimum. The voltage control is supplied by a variac.

2. In order to give additional speed control an intermittent circuit control system is used.

3. Reversal of the longitude motor is accomplished by reversing the direction of current in the field with respect to the armature by means of a double-pole, double-throw, center-locking, longitude direction control switch. (The central switch position is "off.")

(*c*) TIME DRIVE MOTOR AND CONTROLS. (*See figures 7 and* 11.)—The time drive motor is a synchronous split-phase motor which operates on 110 volts at 60 cycles and draws .96 amperes when in operation at full load. It is supplied with a gear reducer having a 900 to 1 gear ratio which cuts the output shaft speed down to 2 rpm from 1800 rpm at the armature. The time drive motor is controlled by the master switch, the navigation switch, and the time switch.

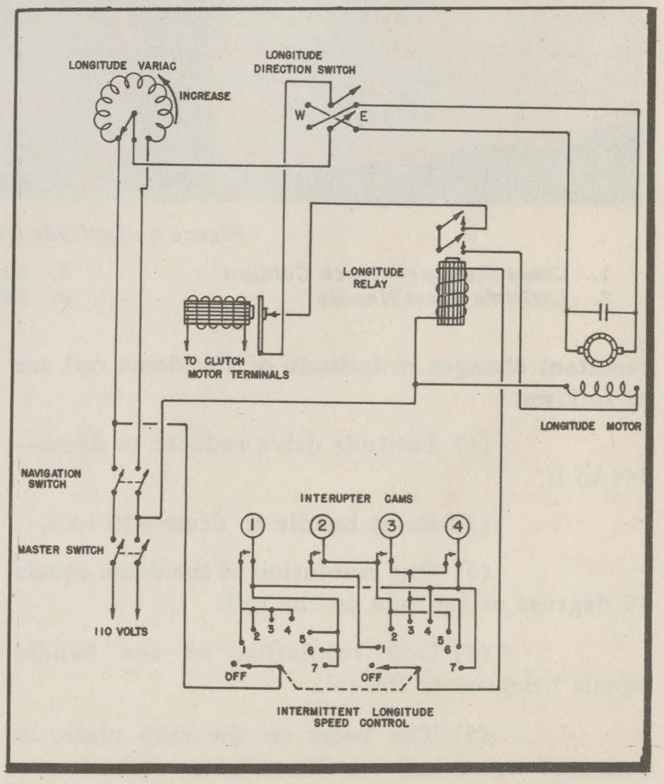

Figure 10—Wiring Diagram, Longitude Motor and Controls

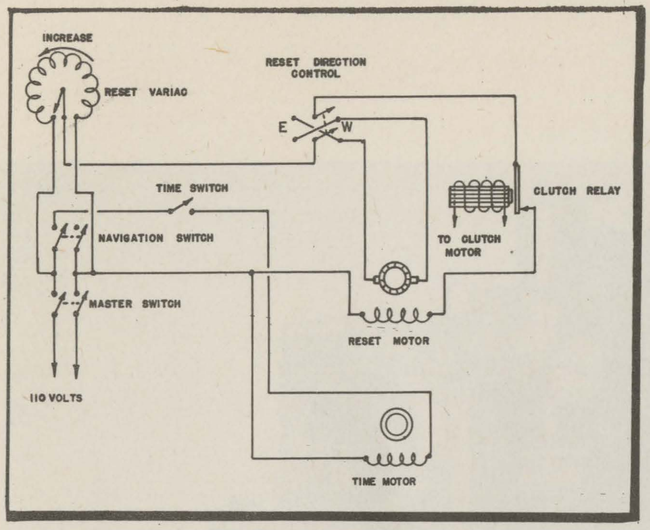

Figure 11—Wiring Diagram, Dome Reset Motor and Control, and Time Motor Circuit

(*d*) DOME CLUTCH MOTOR AND CONTROLS. (*See figures 12 and 13.*)

1. The clutch motor is a synchronous split-phase motor which operates on 110 volts at 60 cycles. It draws approximately .66 amperes and is rated at 1/70 HP. It is controlled by three micro-switches operated by cams, and the clutch control switch in the upper left-hand desk drawer control panel. This switch has three positions: normal, neutral, and reset. In the normal position voltage is applied to the motor until the clutch reaches the normal drive position at which time the cam causes the "normal position" micro-switch to open and the clutch motor stops. If the clutch control switch is now placed in the neutral position, voltage again will be applied to the motor until the clutch reaches the neutral position at which time the "neutral position" micro-switch will open and the circuit to the motor will again be dead. The same process will again be repeated in the reset position of the clutch control switch; however, this time the circuit will be opened when the clutch is in the reset position.

2. As a safety measure a relay has been placed across the clutch motor so that whenever voltage is applied to the clutch motor and the motor is running, the relay operates. This opens the longitude motor and reset motor circuits so that whenever the clutch position is being changed the longitude motor and reset motor are inoperative even though their respective controls may be in an operative position.

3. Indicator lamps are supplied in order that the operator can be sure in which position the clutch has been placed. These three lamps are located on the desk dome control panel immediately above the three positions of the clutch control switch. An additional neutral position indicator is located on the building wall at the fuselage level of the stairway so that anyone desiring to rotate the dome by hand can be sure that the clutch is in the neutral position. These lamps are placed in the circuit in such a manner that they are shorted by their respective position micro-switches. When the clutch reaches a position which opens one of the micro-switches the lamp, which has been shorted out by this micro-switch, is now energized and, of course, it lights.

(*e*) DOME RESET MOTOR AND CONTROLS. (*See figure 13.*)

1. The dome reset drive motor is of the same type as the latitude and longitude motors and the same precautions should be observed in reducing speed by voltage control. [See section III, par. 1*d*(9)(*b*).] The gear ratio, however, is 36 to 1 and hence the output shaft speed is higher, turning the dome about one-fourth revolution per minute in either direction. If power is supplied to the reset motor when disengaged, it will idle without harm.

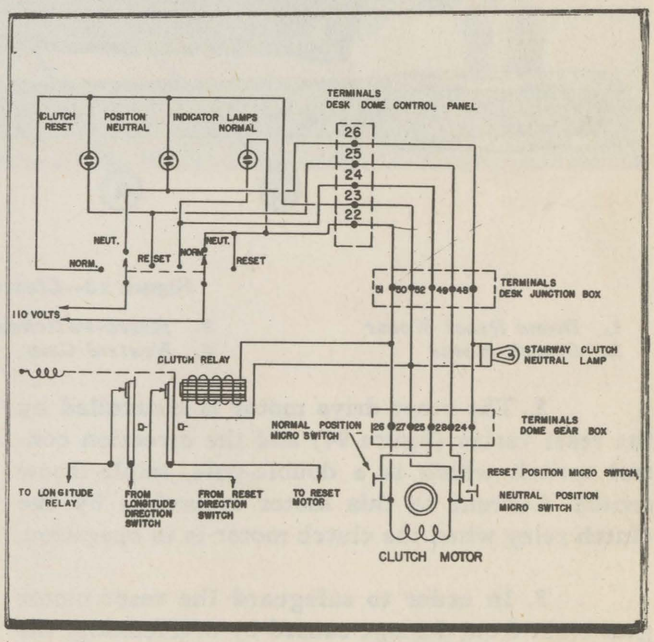

Figure 12—Wiring Diagram, Clutch Motor and Controls

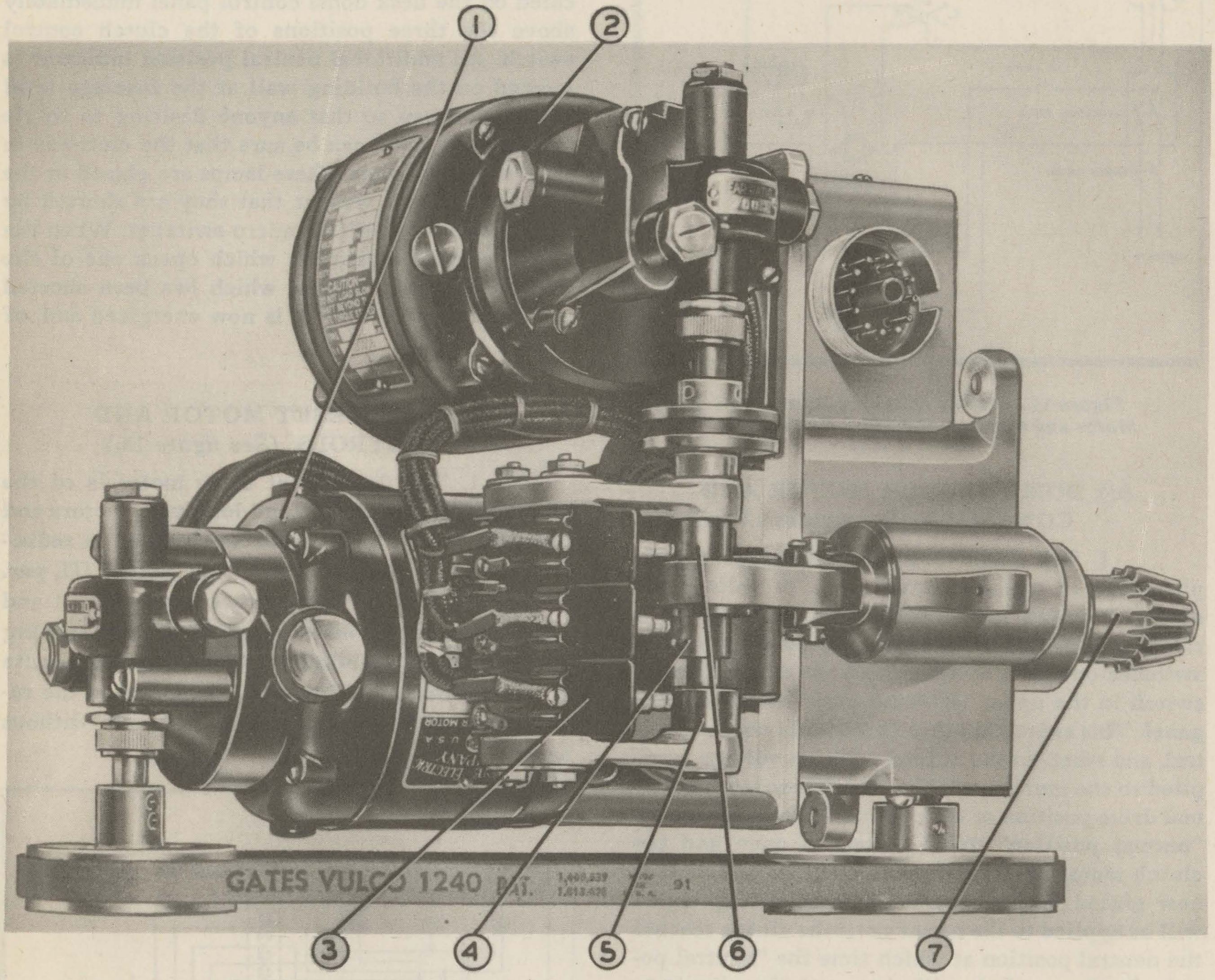

Figure 13—Clutch Reset Mechanism

1. *Dome Reset Motor*
2. *Clutch Motor*
3. *Micro-switches*
4. *Neutral Cam*
5. *Normal Cam*
6. *Reset Cam*
7. *Shear Pin*

2. The reset drive motor is controlled by the reset variac (figure 94) and the direction control switch which is a double-pole, triple-throw switch. Current to this motor is broken by the clutch relay when the clutch motor is in operation.

3. In order to safeguard the reset motor gear train from damage caused by overloading, the bevel pinion gear on the reset drive is secured to its shaft by a hollow aluminum shear pin (figure 13). If the dome is accidentally turned by hand when the dome reset drive clutch is engaged, the pin may shear. To replace this pin, remove the reset motor and reset mechanism housing. The shaft and pinion come away from the gear case with the housing, and the pin may then be replaced. If the dome is accidentally turned by hand when the time and longitude drive is engaged, the clutch will slip, but a severe load will be imposed on the gear train.

(10) DOME POSITION INDICATORS. (*See figure* 14.)

(*a*) There are four teletorque systems used to indicate the position of the dome. Each system involves the use of two teletorques (four in the case of the time system). The four systems are the latitude, longitude, time and LHA Aries teletorque systems. In each case there is a transmitter teletorque on the dome gear box which drives a receiver teletorque in the desk instrument panel (and in the pilot's and navigator's panels in the case of time). (See figures 14, 23, 25 and 92.) One of the 32-volt supply transformers for the four teletorques is located on the rear of the desk instrument panel; the other is in the tower junction box. All the armatures are in parallel (with the exception of the pilot's and navigator's time teletorques which have a separate armature supply in the tower junction box); and in addition, terminal (1) of the fields of all the teletorques are a common ground and tied to (G) of the armature. This results in a saving in the number of wires necessary to connect the transmitter and receiver teletorques, but does not change the characteristics of the teletorques in operation. (See wiring diagrams, figures 14 and 57.)

(*b*) If any of the teletorque indicators run in reverse rotation, i. e., if the latitude indication decreases when the latitude motor is being driven so that the dome travels northward, this may be corrected by transposing terminals (2) and (3) on either the receiver or transmitter teletorque.

(11) THE TELETORQUES.

(*a*) TIME.—This teletorque is driven by the time drive motor and has three "clocks" dependent on it. Of these, one is on the pilot's panel, one on the navigator's, and one on the desk instrument panel.

(*b*) LONGITUDE.—This teletorque transmits the longitude drive to the longitude indicator on the operator's panel, indicating the observer's change of longitude in degrees and minutes, east or west.

(*c*) LHA ARIES.—Since LHA Aries is a result of both lapse of time (rotation of the earth) and the observer's motion in terms of change of longitude, the LHA Aries must be the result of both the time drive and longitude drive. It is, therefore, geared to the main shaft and transmits movement and position of the dome in degrees and minutes to the indicator on the desk instrument panel.

(*d*) LATITUDE.—The latitude teletorque, which is mounted above the west-side top runway on the outer radius of the dome rail, receives its motion through a friction driven roller which bears against the runway. The circumference of the roller is equivalent to one degree on the rail. In order to prevent errors due to slippage of the roller on the rail, a series of small holes are drilled at 15-minute intervals of arc along the runway. Protruding from the roller are four fingers spaced at 90 degrees to each other, or in terms of the rail, at 15-minute intervals. The roller acts as an intermittent gear. Any small errors arising from slippage are corrected every 15 minutes of arc as measured along the surface of the rail. (See figure 3.)

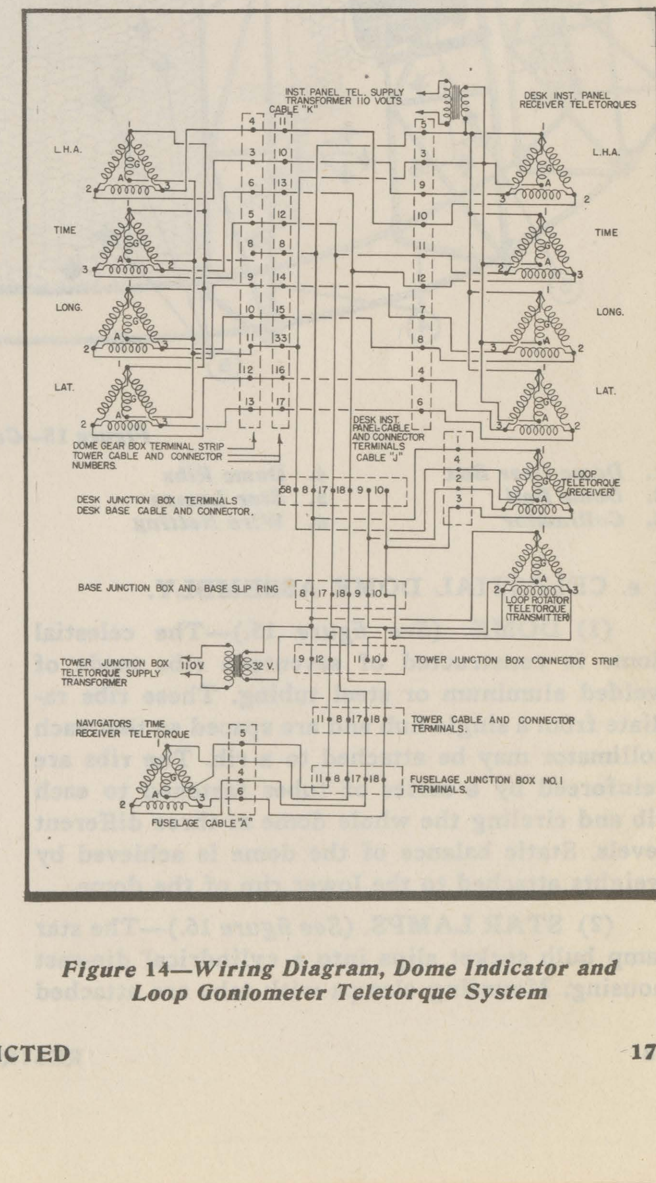

Figure 14—Wiring Diagram, Dome Indicator and Loop Goniometer Teletorque System

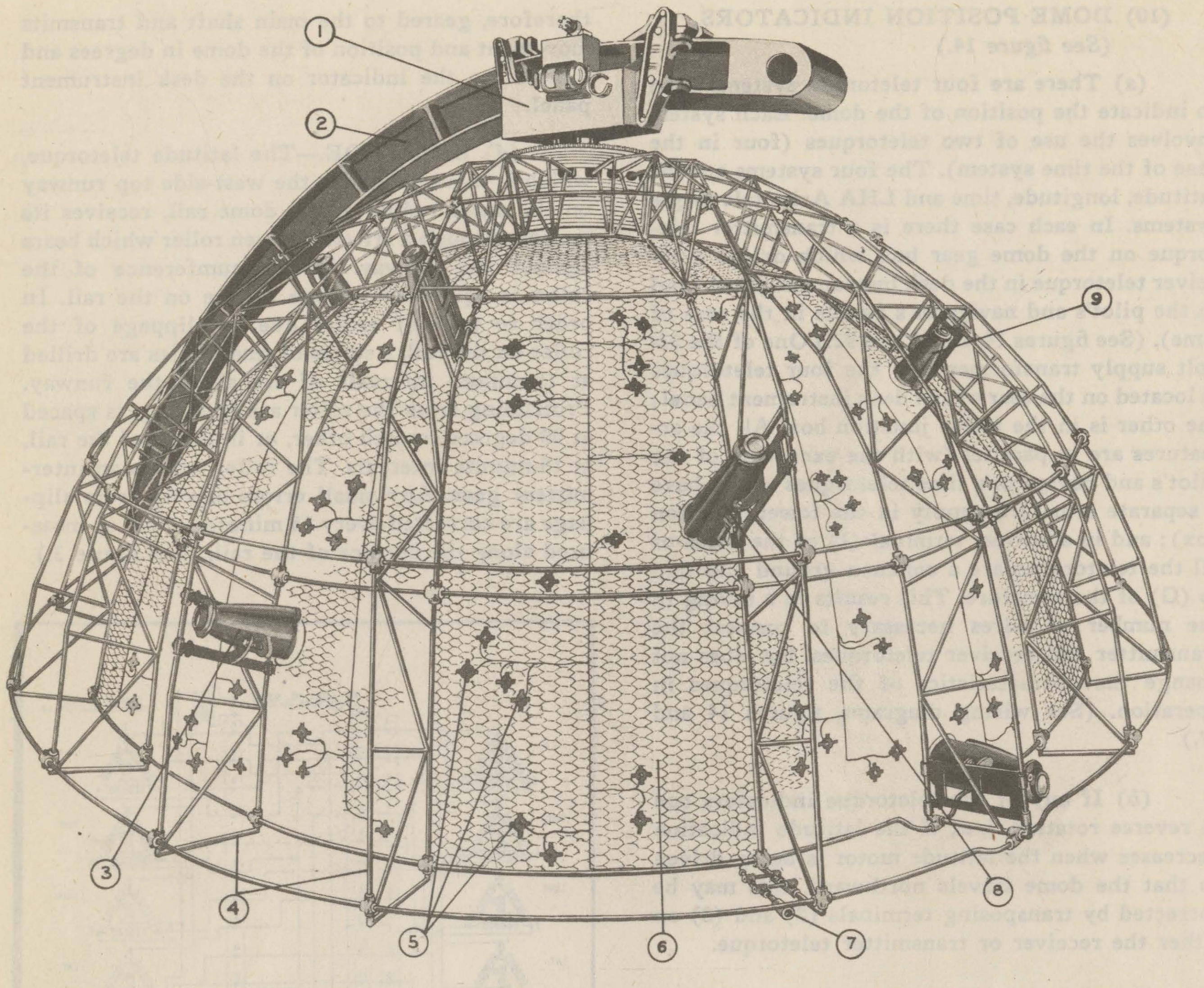

Figure 15—Celestial Dome

1. *Dome Gear Box*
2. *Dome Rail*
3. *Collimator*
4. *Dome Ribs*
5. *Star Lamps*
6. *Wire Netting*
7. *Aries Projector Indicators*
8. *Collimator*
9. *Collimator*

e. CELESTIAL DOME ASSEMBLY.

(1) DOME. (*See figure* 15.)—The celestial dome is constructed of seventeen ribs made of welded aluminum or steel tubing. These ribs radiate from a single hub and are spaced so that each collimator may be attached to a rib. The ribs are reinforced by a series of tubes fastened to each rib and circling the whole dome at three different levels. Static balance of the dome is achieved by weights attached to the lower rim of the dome.

(2) STAR LAMPS. (*See figure* 16.)—The star lamp bulb socket slips into a cylindrical die-cast housing. Mounting clamps with tabs are attached to the housing so that the lamps may be soldered to the wire mesh of the dome. The bulb socket, in which is mounted a Mazda No. 51, 6–8 v 1 cp bulb, can be easily removed to make a replacement should the bulb burn out. The cap contains one or more filters of blue lamicoid (synthetic material of resinous base) through which the light passes, and a brass disc with a .010 inch aperture. The appearance of the star in color and magnitude is produced by light filters. The filters used are .012, .018, or .025 inches thick, color coated on both sides. By use of one or two filter discs the amount of light is controlled to produce the effect of first,

second, third, or fourth magnitude stars. The discs are held in place by a felt ring on the inside of a die-cast retainer which slips over the end of the housing.

(3) COLLIMATOR. (*See figures* 17, 18, *and* 19.)

(*a*) The framework of the collimator is a cylindrical casting of Dow metal. Set in its face is a 5-inch achromatic lens. The bulb housing is situated outside the main body of the casting with the bulb facing toward the rear of the collimator. A mirror, set in the rear end of the casting, serves to direct the light back through the lens.

(*b*) The bulb housing contains two lamicoid discs of blue plastic and two screens pierced by small apertures. The small orifices or stop apertures regulate the amount of light allowed to pass out through the lens. The light source in the collimator is a bayonet-base 6-volt bulb.

(*c*) When a bulb burns out, a new one may be inserted without disturbing the internal adjustment of the instrument. This adjustment is established at the factory and the importance of leaving it undisturbed cannot be over-emphasized.

(4) ELECTRICAL CONNECTIONS TO STAR LAMPS AND COLLIMATORS.

(*a*) The case of the collimator, which is fastened to a dome rib, is the common connection for

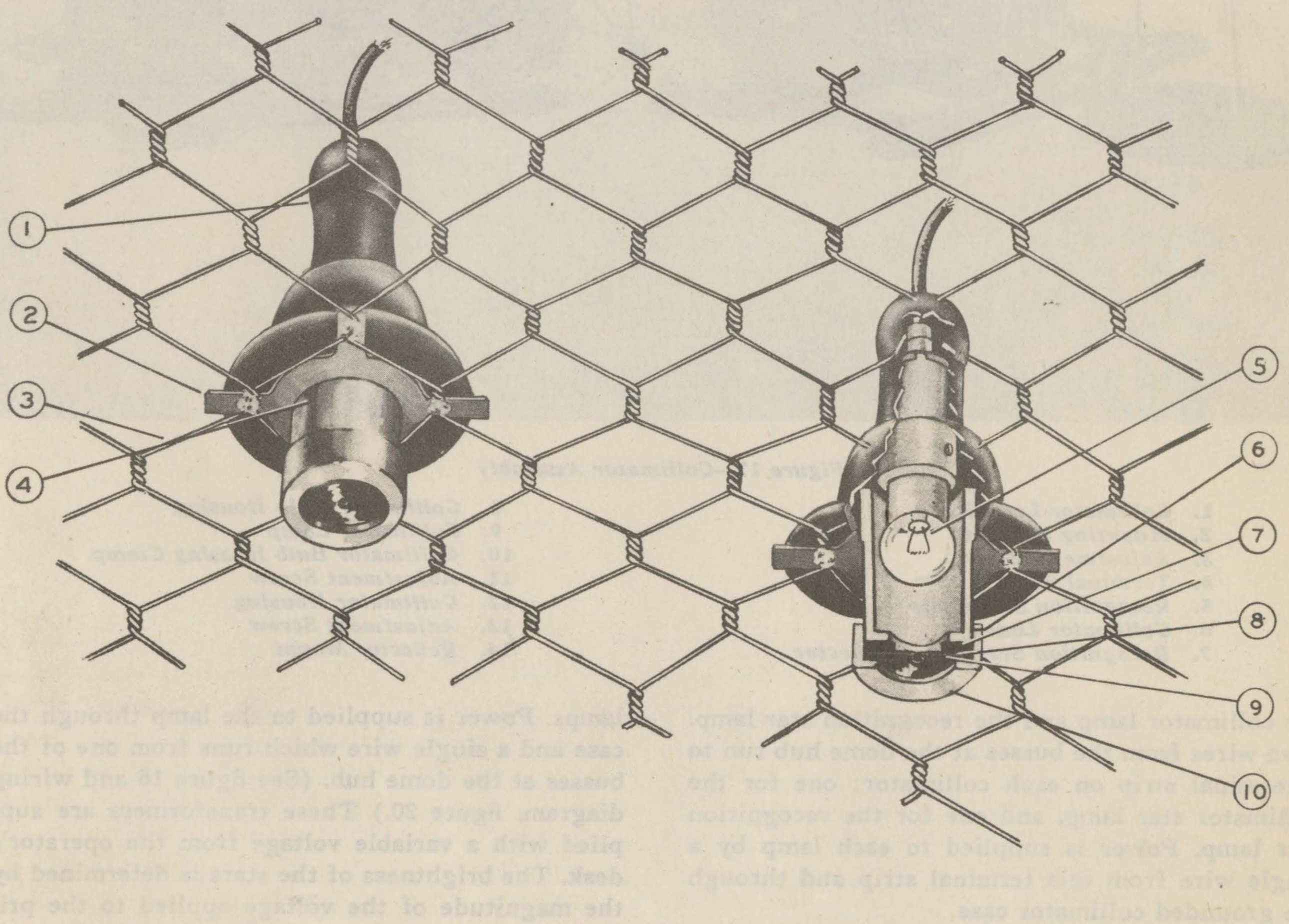

Figure 16—Star Lamp

1. *Rubber Nipple*
2. *Mounting Clamp*
3. *Wire*
4. *Socket*
5. *Bulb*
6. *Housing*
7. *Felt Washer*
8. *Lamicoid Disc*
9. *Aperture Disc*
10. *Retainer*

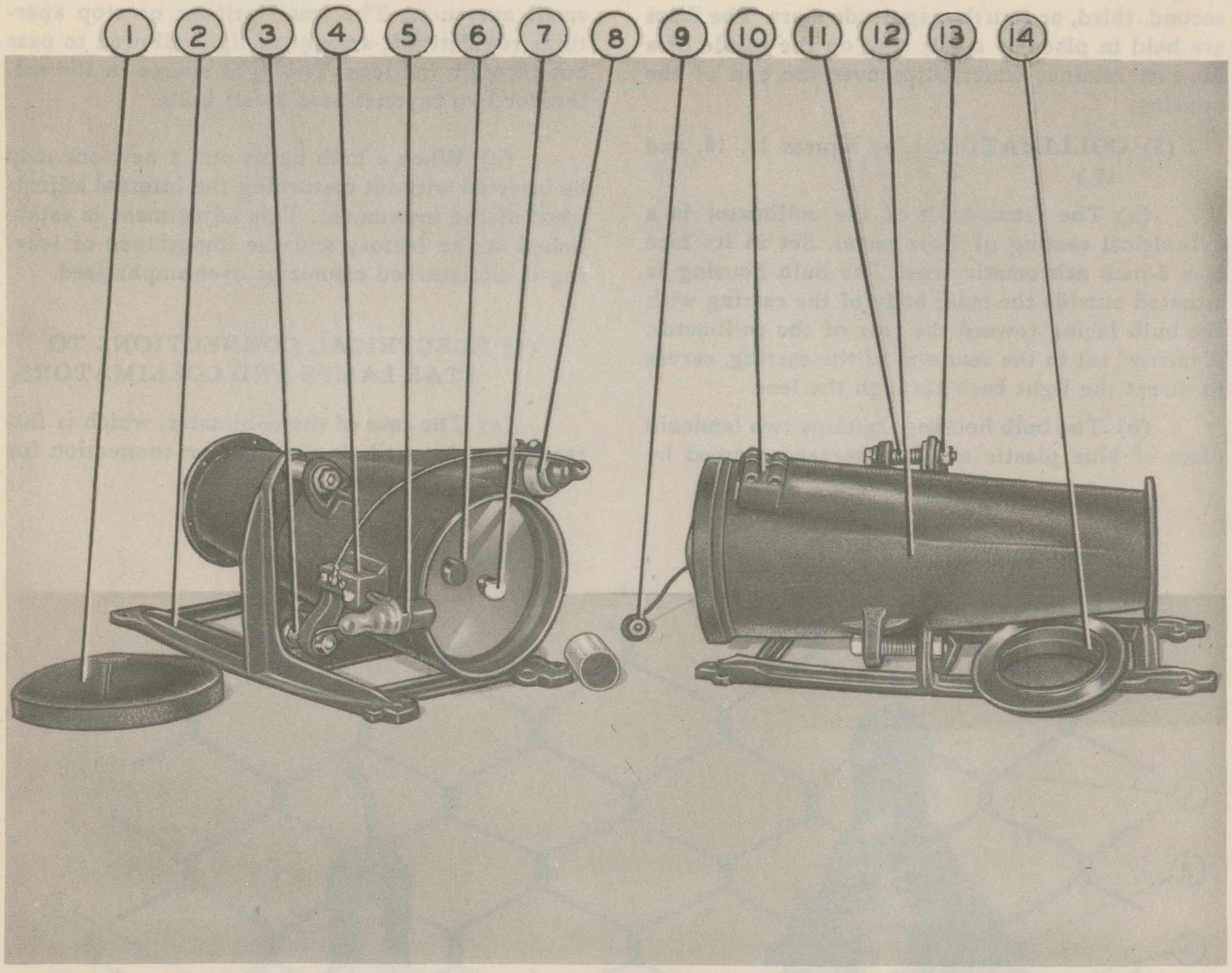

Figure 17—Collimator Assembly

1. *Collimator Lens Cover*
2. *Mounting Bracket*
3. *Adjustment Screw*
4. *Terminal Block*
5. *Recognition Star Lamp*
6. *Collimator Lens*
7. *Recognition Star Lamp Reflector*
8. *Collimator Bulb Housing*
9. *Collimator Lamp*
10. *Collimator Bulb Housing Clamp*
11. *Adjustment Screw*
12. *Collimator Housing*
13. *Adjustment Screw*
14. *Reflector Mount*

the collimator lamp and the recognition star lamp. Two wires from the busses at the dome hub run to a terminal strip on each collimator; one for the collimator star lamp, and one for the recognition star lamp. Power is supplied to each lamp by a single wire from this terminal strip and through the grounded collimator case.

(*b*) The case of each star lamp is mounted on the dome wire mesh and soldered. The wire mesh is therefore a common connection to all star lamps. Power is supplied to the lamp through the case and a single wire which runs from one of the busses at the dome hub. (See figure 16 and wiring diagram, figure 20.) These transformers are supplied with a variable voltage from the operator's desk. The brightness of the stars is determined by the magnitude of the voltage applied to the primary windings of these transformers. This voltage is controlled by the star variac and supplied to dome gear box terminal block and from there through slip rings to the stars. The collector ring

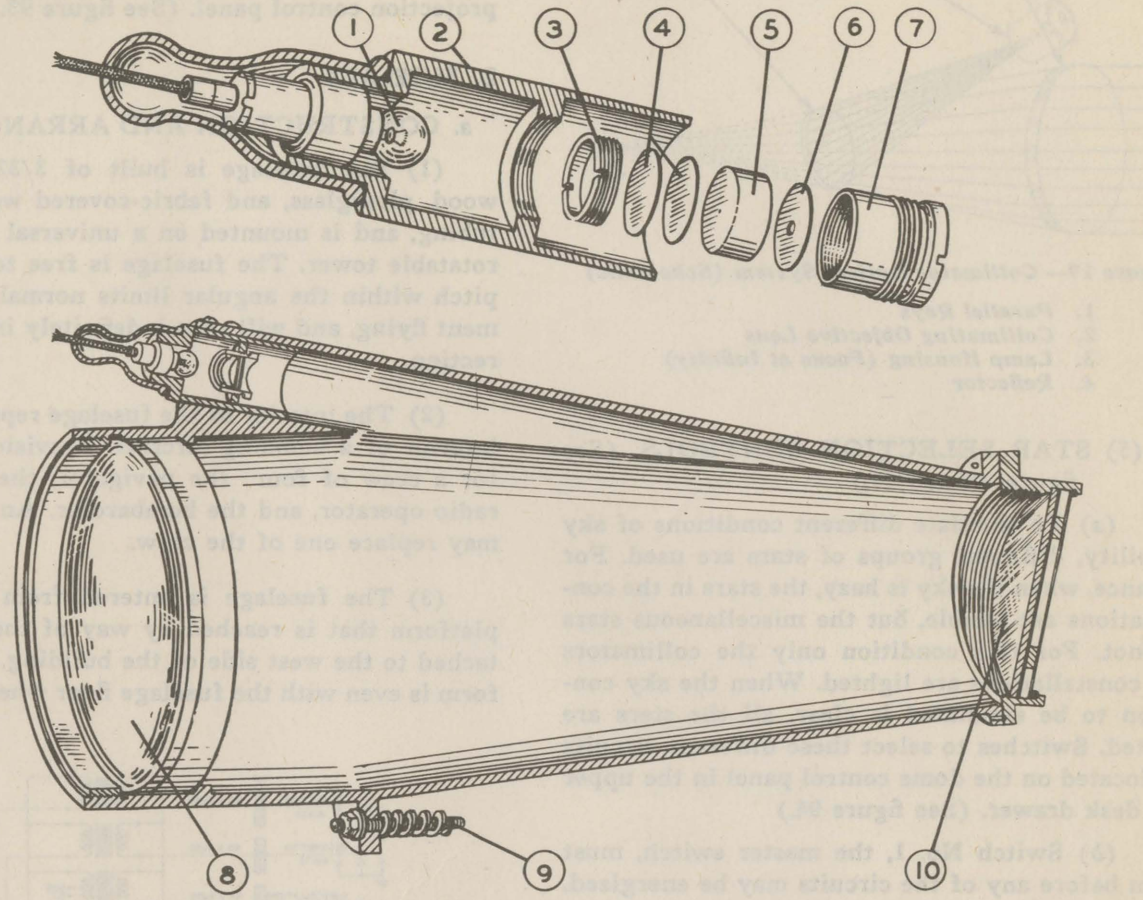

Figure 18—Collimator Cross Section

1. *Mazda No. 51, 6-Volt 1 cp Bulb*
2. *Lamp Housing*
3. *Retainer Ring*
4. *Blue Lamicoids (2)*
5. *Aperture Cup*
6. *Aperture Disc*
7. *Filter Housing*
8. *Collimator Lens*
9. *Mounting and Adjusting Screws*
10. *Collimator Reflector*

brush assembly is mounted on an arm fixed to the main gear box, and extends downward parallel to the main shaft. It is so positioned as to bring the brushes opposite collector rings mounted on the shaft.

(*c*) The actual connections at the dome are shown in the wiring diagram (figure 20). The primary windings of the transformers are provided with three taps so that the desired maximum voltage may be obtained, thus regulating the relative brightness of the different groups of stars. The available taps result in 5.0, 5.1, and 5.25 volts at the secondary output terminals. When taps are changed on transformers that are used in parallel be sure to change the taps on **both** transformers.

(*d*) The coding and connections of the star lamps and collimators to the busses are as follows:

System	*Coding*	*Buss*
Collimators	black	first (top)
Recognition stars	white	second
Constellations	green	third
Miscellaneous	red	fourth
Common	yellow	fifth

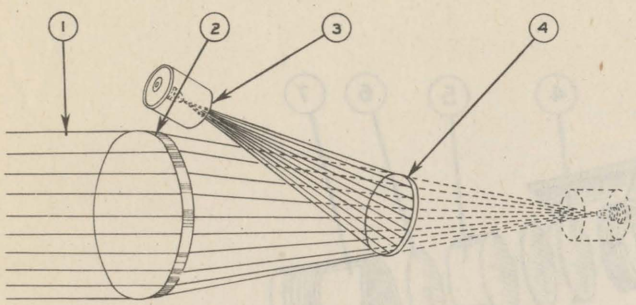

Figure 19— Collimator Optical System (Schematic)

1. *Parallel Rays*
2. *Collimating Objective Lens*
3. *Lamp Housing (Focus at Infinity)*
4. *Reflector*

(5) STAR SELECTION CONTROLS. (*See figures* 93 *and* 94.)

(*a*) To simulate different conditions of sky visibility, different groups of stars are used. For instance, when the sky is hazy, the stars in the constellations are visible, but the miscellaneous stars are not. For this condition only the collimators and constellations are lighted. When the sky condition to be simulated is clear, all the stars are lighted. Switches to select these different circuits are located on the dome control panel in the upper left desk drawer. (See figure 94.)

(*b*) Switch No. 1, the master switch, must be on before any of the circuits may be energized. Switch No. 3, marked "constellations," is the control switch for the collimators and the stars forming constellations. Switch No. 4 is a selector switch by which either the collimators only, or collimators and other constellation stars are energized. Stars other than those collimated or in constellations are controlled by switch No. 5. A switch controlling all stars is Switch No. 2 on the projection control panel (figure 93). A selector switch is located on the navigator's instrument panel in the fuselage. It operates a relay in the desk junction box which selects either collimators or recognition stars.

(6) STAR DENSITY CONTROL. (*See wiring diagram, figure* 20.)—Control of the intensity of star illumination is necessary since the heavens would apparently become brighter as the navigator's eyes grew accustomed to the darkness inside the building. To keep the star density or intensity constant to an observer's eyes a variac is provided which controls the primary voltage applied to the transformers supplying the star lamps and collimators. The variac has a range of from zero to 110 volts. This star density control is located in the projection control panel. (See figure 93.)

2. FUSELAGE.

a. CONSTRUCTION AND ARRANGEMENT.

(1) The fuselage is built of 3/32-inch plywood, plexiglass, and fabric-covered welded steel tubing, and is mounted on a universal joint on a rotatable tower. The fuselage is free to bank and pitch within the angular limits normal to instrument flying, and will turn indefinitely in either direction.

(2) The interior of the fuselage represents the interior of a bombing aircraft. Provision is made for a crew of four: the navigator, the pilot, the radio operator, and the bombardier. An instructor may replace one of the crew.

(3) The fuselage is entered from a landing platform that is reached by way of the stairs attached to the west side of the building. This platform is even with the fuselage floor when the fuse-

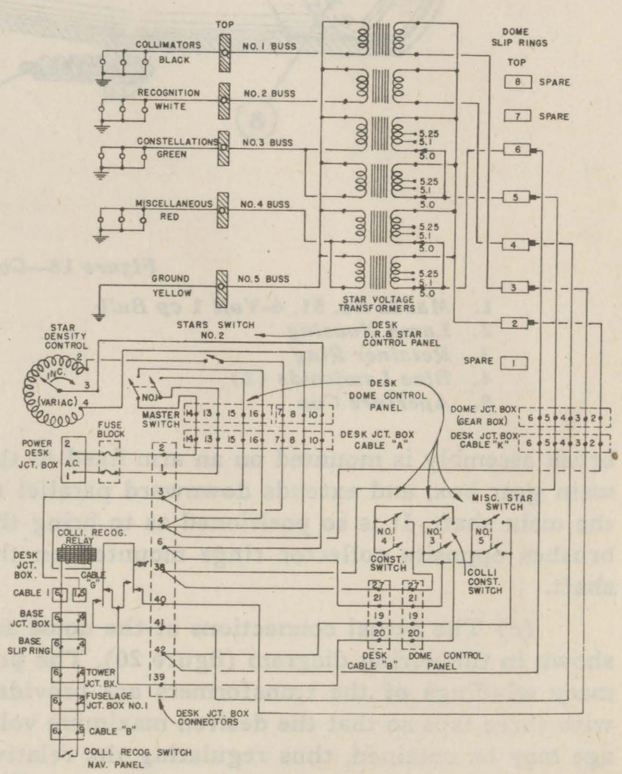

Figure 20—Wiring Diagram, Star Connections and Controls

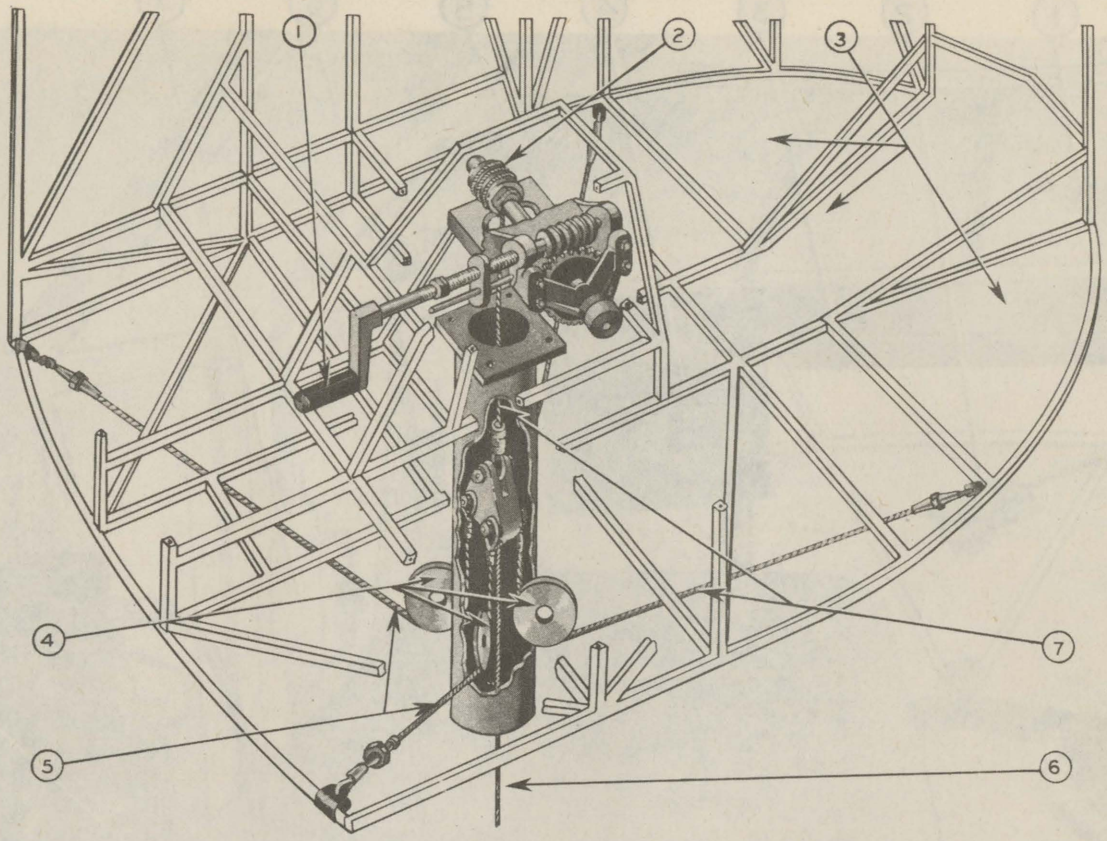

Figure 21—Fuselage Leveling Device

1. *Hand Crank*
2. *Drum*
3. *Bottom of Fuselage*
4. *Pulleys*
5. *Cables*
6. *To Tower Locking Device*
7. *Cable*

lage is locked in the level position. Before disembarking, the Trainer is placed on an east heading, opposite the platform, where it is held in position by the locking device on the base. The fuselage door cannot be opened normally unless the Trainer is locked on the east heading, due to an electric door lock which is in the locked position under all other conditions. (See section III, par. 2*c*)

(4) The Trainer is operated on vacuum supplied by a 2 HP turbine. Banking and pitching are obtained by a system of bellows. Turning is obtained by the use of two vacuum motors.

b. LEVELING DEVICE. (*See figure* 21.)—When the Trainer is turned around to the landing platform, it can be leveled and locked to keep it from turning. This is done by means of the hand crank mounted on the universal joint plate on the right side of the engine control column. Four cables, one from each corner of the fuselage, are brought together at the bottom of the fuselage support tube where they pass over pulley wheels and are joined together into one cable. This cable passes up the hollow fuselage support tube to a drum mounted on the top section of the universal joint plate. The cable drum is operated by the hand crank through a worm gear and worm wheel. By turning the hand crank clockwise, the cable is wound in on the drum and the Trainer is leveled. By winding the handle counterclockwise, the cable is let out and the fuselage becomes free to move about the banking and pitching axes.

c. SOLENOID DOOR LOCK.—The fuselage door is protected by a solenoid lock mounted on the door frame to prevent the crew from opening the door at any time when the Trainer is not in a locked level position on an east heading. The solenoid operates from a micro-switch actuated by the tower locking device. When the Trainer is locked on an east heading the circuit is closed and the solenoid holds the plunger down, thus releasing the door. When the Trainer is in operation a spring locks the latch closed. A short extension on the

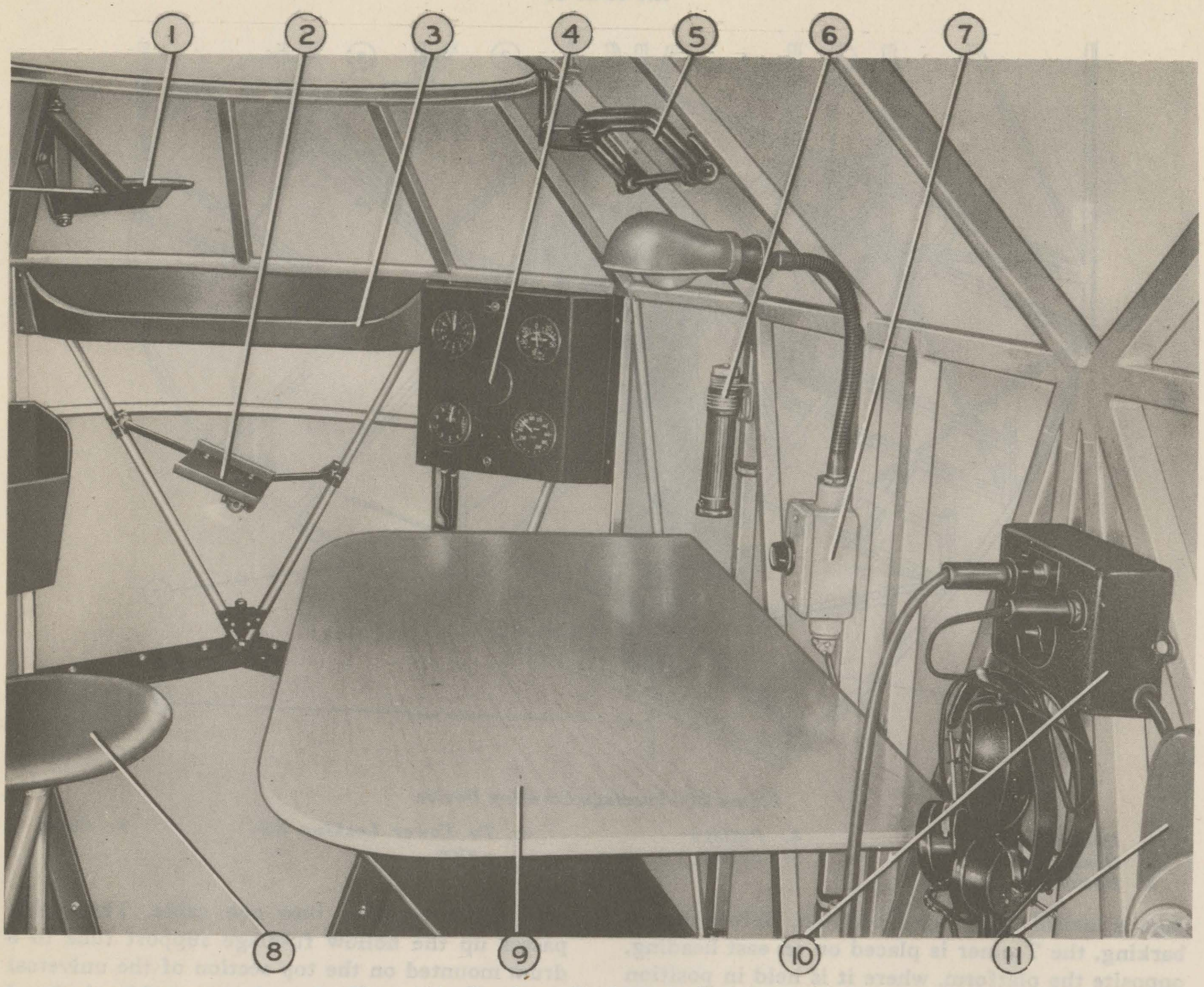

Figure 22—Fuselage—Navigator's Compartment

1. *Astro Compass Mounting Bracket*
2. *Drift Indicator Mounting Bracket*
3. *Navigator's Equipment Tray*
4. *Navigator's Instrument Panel*
5. *Astrograph Mounting Bracket*
6. *Navigator's Fluorescent Light*
7. *Navigator's Table Light*
8. *Navigator's Seat*
9. *Navigator's Table*
10. *Instructor's Interphone Panel*
11. *Instructor's Seat*

latch bar extends out of the cover of the solenoid unit in the fuselage so the door can be released in emergency without operating the tower locking device.

d. LOCATION OF EQUIPMENT.

(1) NAVIGATOR'S COMPARTMENT. (*See figure* 22.)

(*a*) The navigator is provided with an instrument panel, adjustable seat, collapsible work table, map case, trays for gear, mount for a drift indicator, a bomb sight, interphone equipment, and brackets for the astro compass and astrograph. The following instruments are mounted on the navigator's panel (figure 24):

1. Clock (dome-driven).
2. Standard Sensitive Altimeter.
3. Air-Speed Indicator.
4. Outside Air Temperature Gage (simulated).
5. Magnetic Compass (remote-indicating).

(*b*) The compartment is covered with a standard plexiglass navigator's dome.

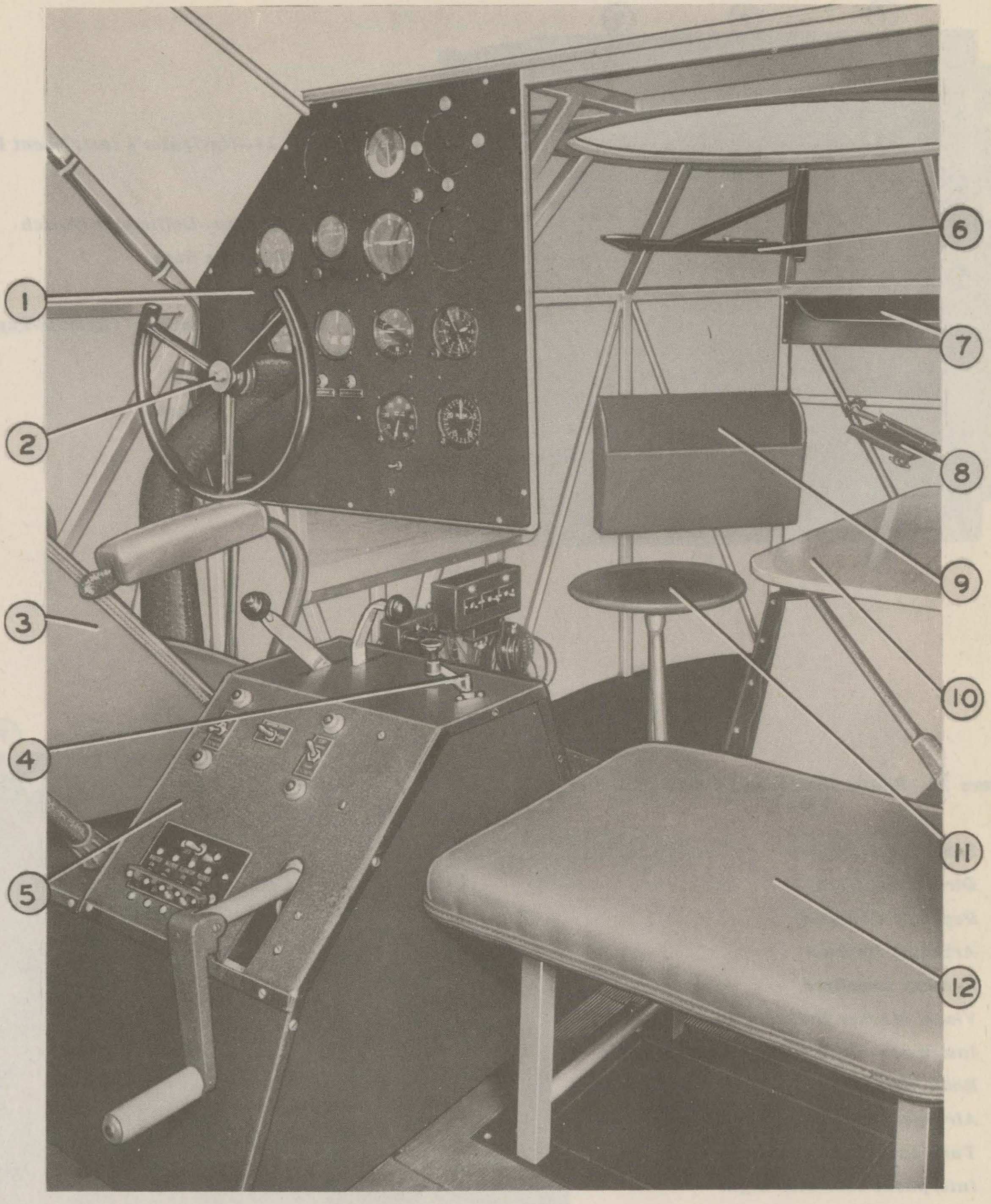

Figure 23—Fuselage—Pilot's Compartment

1. *Pilot's Instrument Panel*
2. *Control Wheel*
3. *Pilot's Seat*
4. *Rough Air Control*
5. *Control Column Cover Plate*
6. *Astro Compass Mounting Bracket*
7. *Navigator's Equipment Tray*
8. *Drift Indicator Mounting Bracket*
9. *Navigator's Equipment Tray*
10. *Navigator's Table*
11. *Navigator's Seat*
12. *Instructor's Seat*

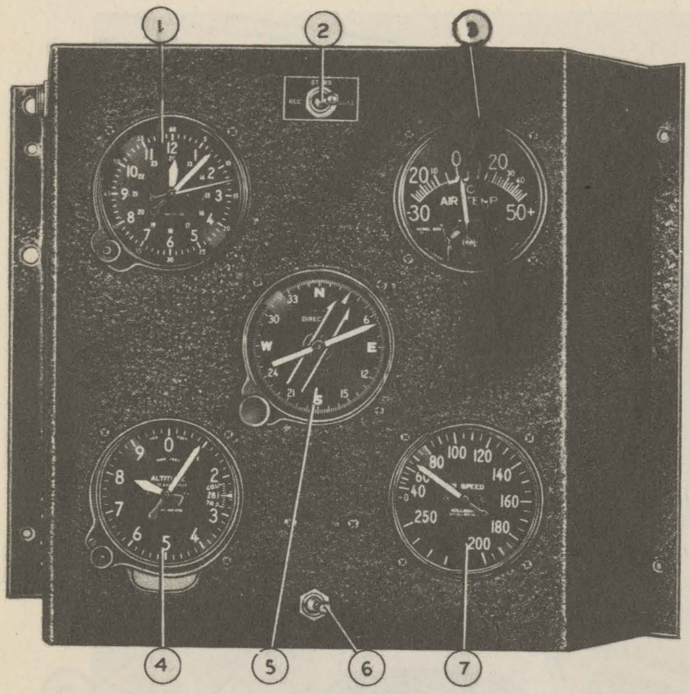

Figure 24—Navigator's Instrument Panel

1. *Clock*
2. *Recognition—Collimator Switch*
3. *Temperature Gage*
4. *Altimeter*
5. *Magnetic Compass (Remote-Repeating Type)*
6. *Vibrator Switch*
7. *Air-Speed Indicator*

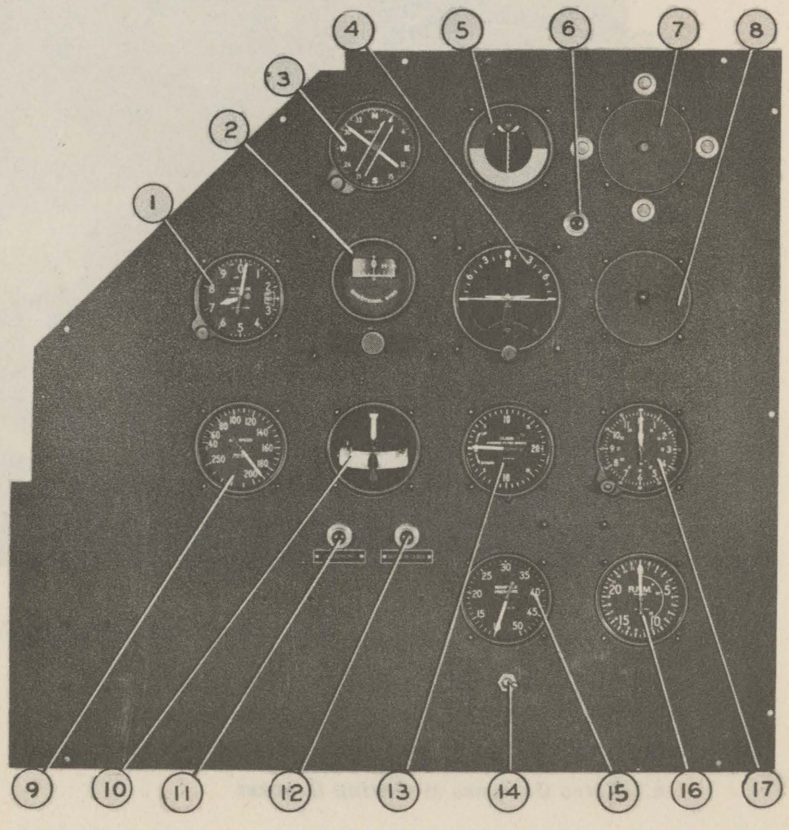

Figure 25—Pilot's Instrument Panel—Front View

1. *Sensitive Altimeter*
2. *Directional Gyro*
3. *Repeater Compass*
4. *Artificial Horizon*
5. *Runway Localizer*
6. *Visual Marker Indicator Light*
7. *Instrument Landing Approach Indicator*
8. *Radio Compass*
9. *Air-Speed Indicator*
10. *Turn and Bank Indicator*
11. *Interphone Indicator Light*
12. *Bomb Release Indicator*
13. *Vertical Speed Indicator*
14. *Vibrator Switch*
15. *Manifold Pressure Indicator*
16. *Tachometer*
17. *Clock*

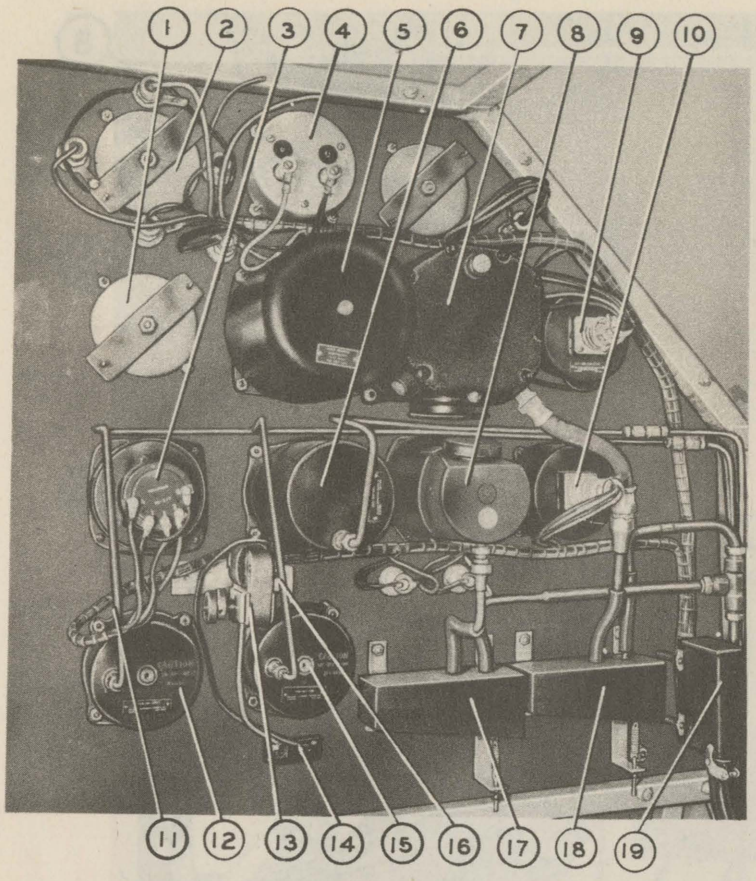

Figure 26—Pilot's Instrument Panel—Rear View

1. *Radio Compass*
2. *Instrument Landing Approach Indicator*
3. *Clock*
4. *Runway Localizer*
5. *Artificial Horizon*
6. *Vertical Speed Indicator*
7. *Directional Gyro*
8. *Turn and Bank Indicator*
9. *Altimeter*
10. *Air-Speed Indicator*
11. *Bleed Hole—Tachometer*
12. *Tachometer*
13. *Vibrator Motor*
14. *Vibrator Switch*
15. *Manifold Pressure Indicator*
16. *Bleed Hole—Manifold Pressure*
17. *Regulating Bellows*
18. *Regulating Bellows*
19. *Jones Plug Connector*

(2) PILOT'S COMPARTMENT. (*See figure* 23.)

(*a*) The pilot is provided with a seat, controls, instrument panel equipped for instrument flying, interphone, and radio equipment. The pilot's controls include throttle, propeller pitch control, rudder pedals, and wheel control column. The instruments on the pilot's panel (figure 25) are as follows:

1. Tachometer
2. Manifold Pressure Gage
3. Air-Speed Indicator
4. Artificial Horizon
5. Vertical Speed Indicator
6. Clock (dome-driven)
7. Standard Sensitive Altimeter
8. Directional Gyro
9. Turn and Bank Indicator
10. Magnetic Compass (remote-indicating)
11. Pilot Direction Indicator (controlled by bombardier)
12. Instrument Landing Indicator

(*b*) The pilot's panel divides the navigator's compartment from the rear compartment, one crew member, or the instructor, and the pilot sitting amidship, the navigator in the front, and the radio operator back of the pilot.

(3) RADIO OPERATOR'S COMPARTMENT. (*See figure* 27.)

(*a*) The radio operator is provided with a seat, work table, a panel with microphone jacks, headphone jack, radio-interphone switch, and interphone signal button. A control panel contains the fuselage amplifier and fuselage power supply.

(*b*) The Trainer is equipped with a radio receiver, type SCR-269-A (or Navy DZ-2). Two control panels are supplied; one above the radio operator's table, and the other above the navigator's table.

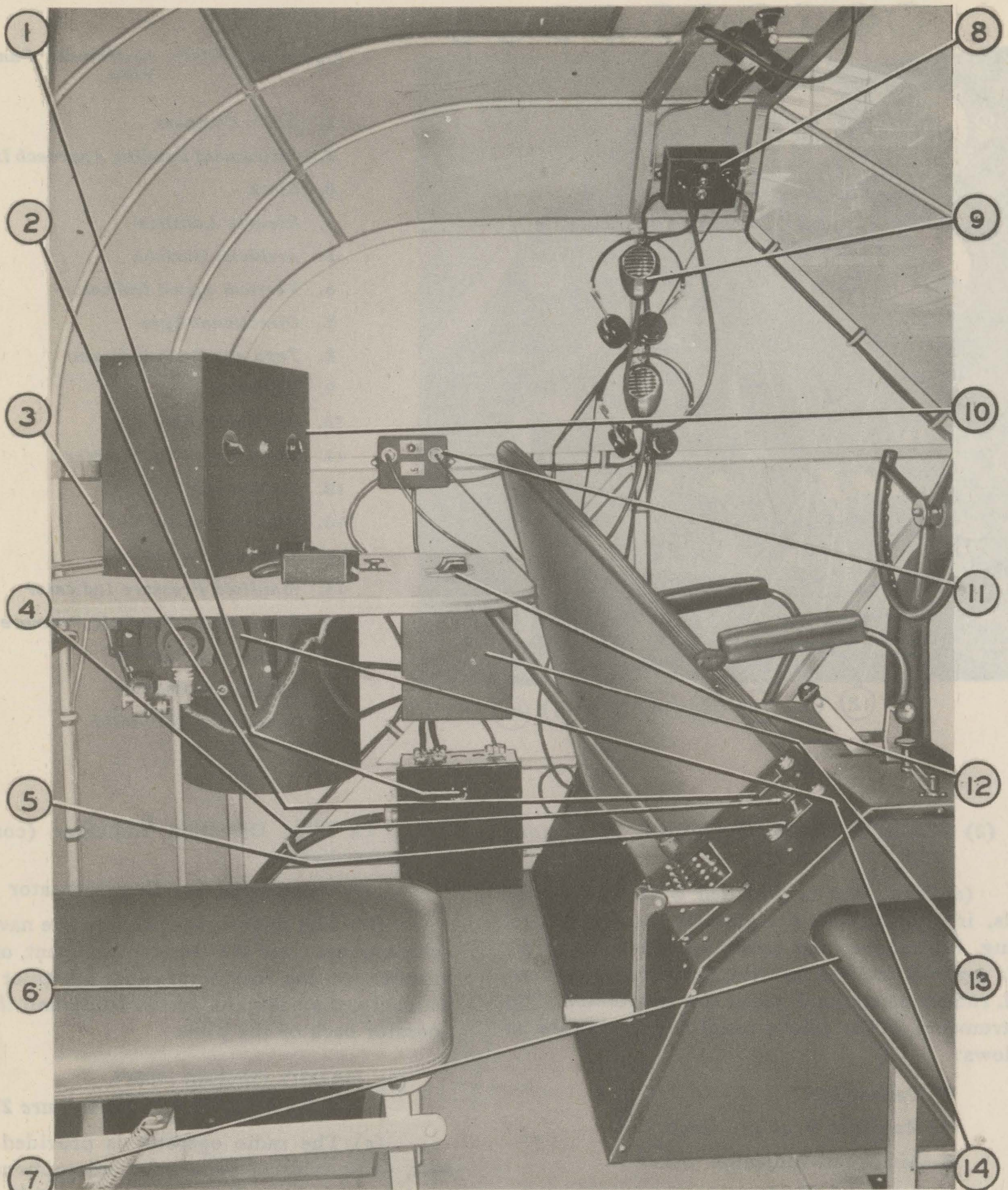

Figure 27—Fuselage—Radio Operator's Compartment

1. *Climb-Dive Tank Assembly*
2. *Fuselage Wall Junction Box*
3. *Landing Gear Indicator*
4. *Ignition Switch*
5. *Flaps Up-Down Switch*
6. *Radio Operator's Seat*
7. *Instructor's Seat*
8. *Pilot's Interphone Panel*
9. *Pilot's and Radio Operator's Microphones*
10. *Interphone Control Unit Assembly*
11. *Radio Operator's Interphone Panel*
12. *Indicated and True Air-Speed Controls*
13. *Air-Speed Transmitter Assembly*
14. *Altitude Compensator Bellows Assembly*

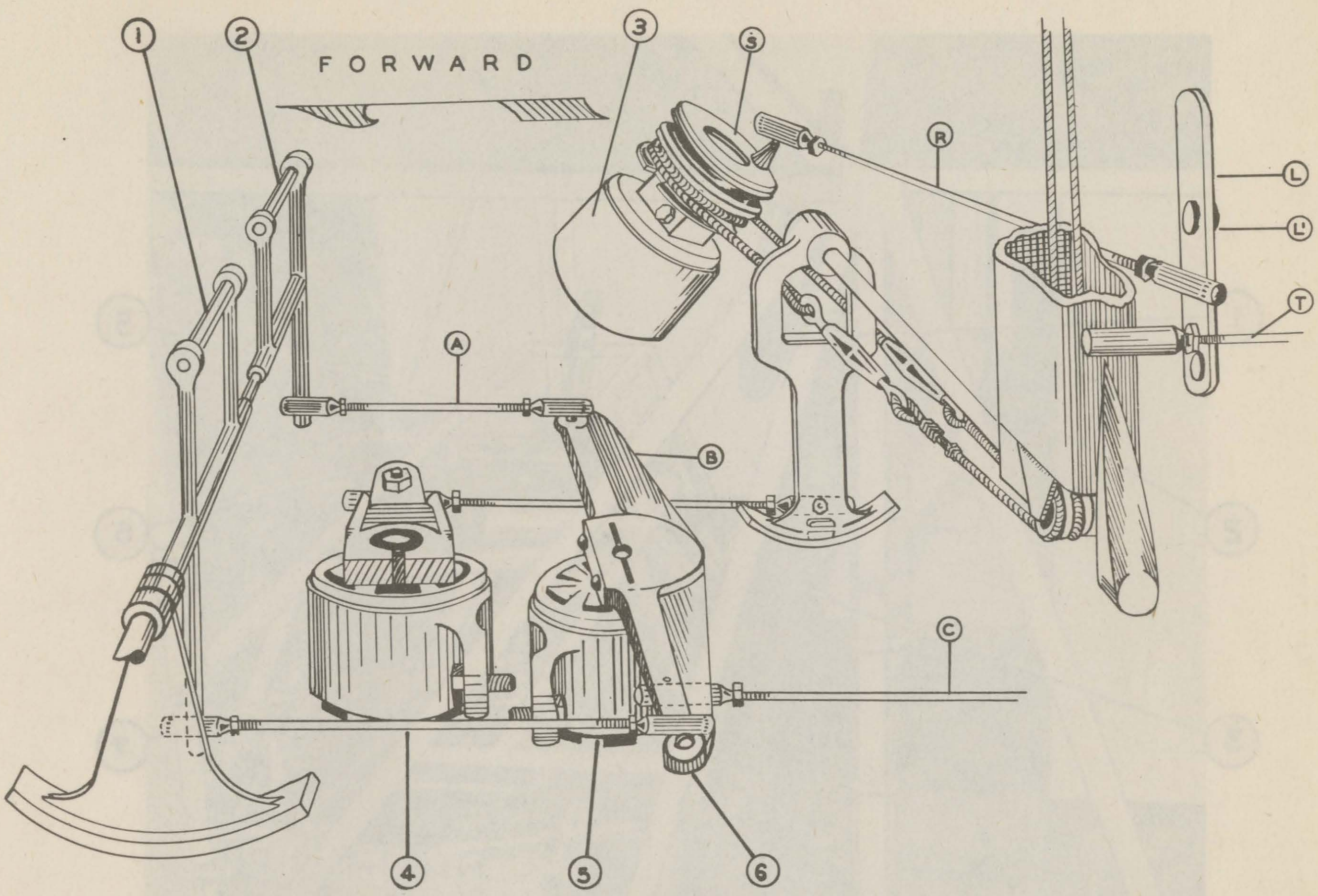

Figure 28—Pilot's Control Assembly

1. *Left Rudder Pedal*
2. *Right Rudder Pedal*
3. *Aileron Slip-stream Simulator*
4. *Elevator Slip-stream Simulator*
5. *Rudder Slip-stream Simulator*
6. *Rudder Bar*

(4) THE INSTRUCTOR'S COMPARTMENT.—The instructor is provided with a folding seat and interphone equipment.

e. CONTROLS AND CONTROL LINKAGE. (*See figures* 28 *and* 31.)

(1) FUSELAGE MOVEMENTS.

(*a*) Movement of the fuselage is caused by movement of the pilot's controls; turning indefinitely in either direction; banking and pitching up to 10 degrees from the horizontal; automatic bank with turn; automatic turn with bank; automatic nose-down-with-turn; automatic tightening of turn when the control column is held behind the neutral position (to prevent nose drop) in a banked turn.

(*b*) The fuselage is actuated by two pairs of bellows that provide banking and pitching action, and two turning motors to rotate the Trainer tower.

(*c*) The main valve assembly is made up of four valves which control the banking, pitching, and turning movements. They are the aileron valve, elevator valve, rudder valve, and turn-tightening valve.

(*d*) Movement of the Trainer about the three axes, in all cases, is obtained through operation of the main valves by spring loaded controls. A movement of any control, or combination of controls, will transmit movement through linkage to the proper valve, or valves. The valves transfer circuits of vacuum and atmospheric pressure to the operating bellows and turning motors. The bottom sections of the aileron, elevator, and rudder valves are cast integrally with the main valve manifold, and receive their supply of vacuum through it.

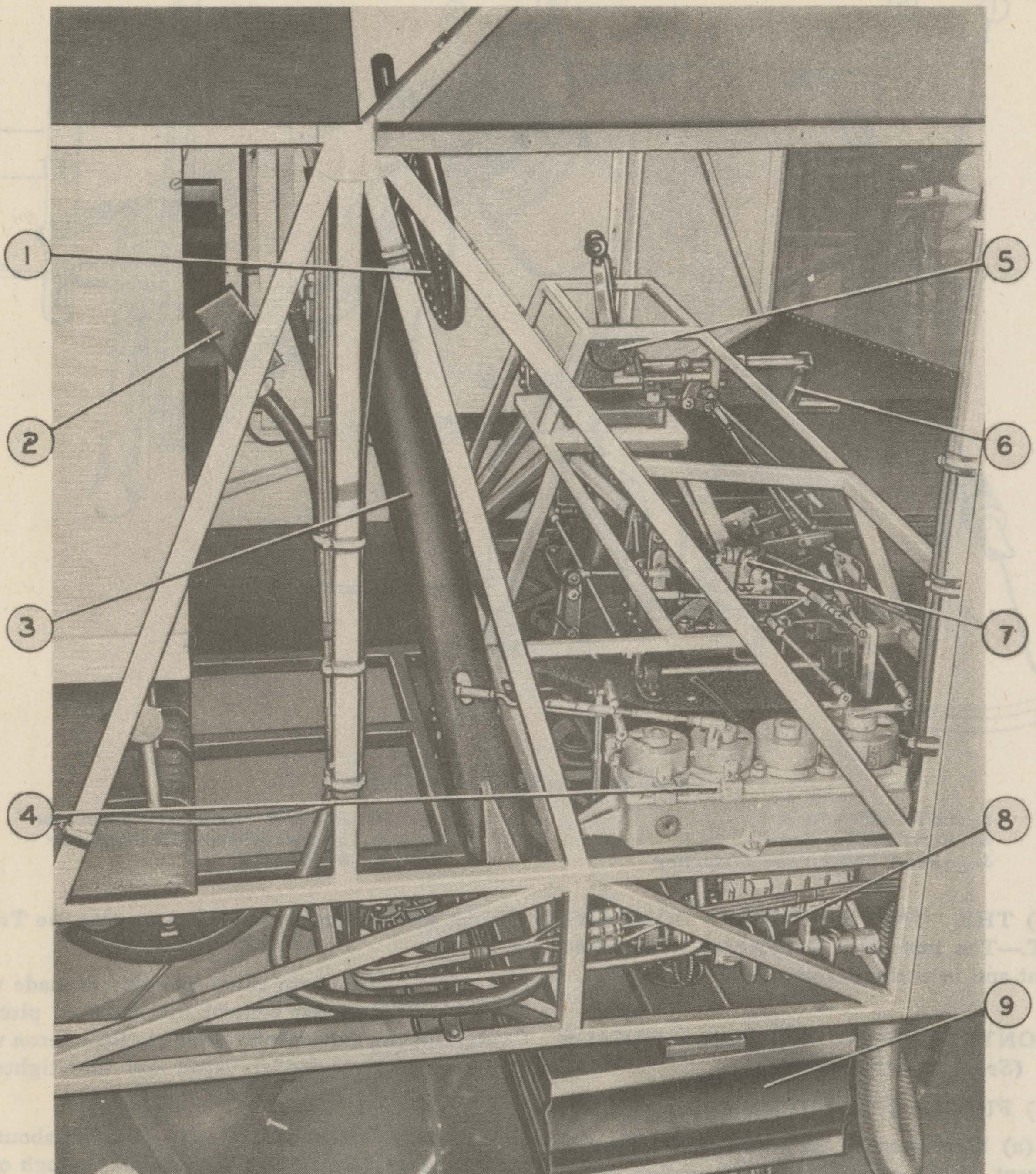

Figure 29—Fuselage Control Mechanism—Left Side View

1. *Pilot's Control Wheel*
2. *Jones Plug Connector—Pilot's Panel*
3. *Control Column*
4. *Main Valve Manifold*
5. *Throttle Lever Assembly*
6. *Fuselage Leveling Device Crank*
7. *Climb-Dive Valve Assembly*
8. *Rough Air Generator*
9. *Left Banking Bellows*

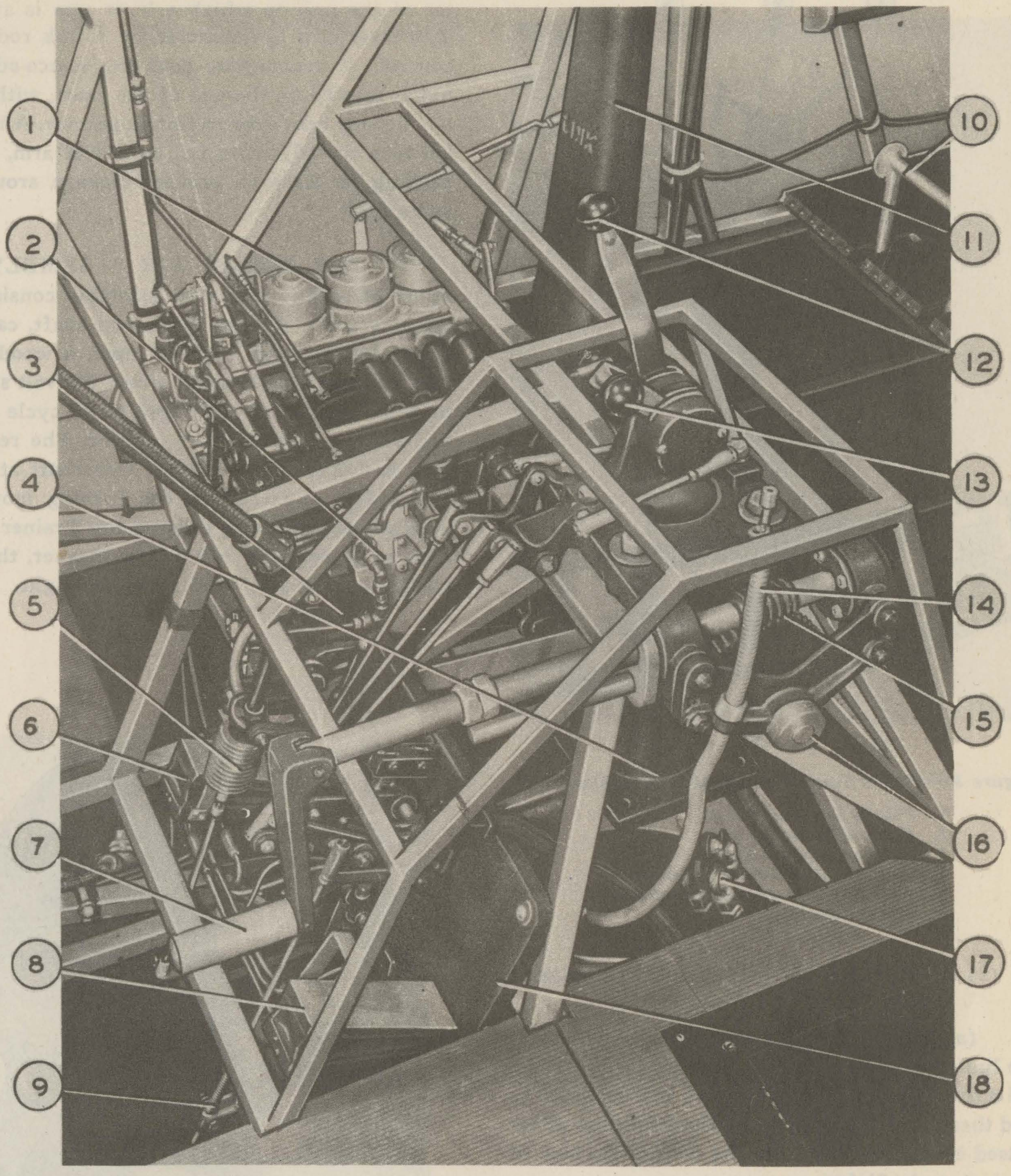

Figure 30—Fuselage Control Mechanism—Right Side View

1. *Main Valve Assembly*
2. *Climb-Dive Valve Assembly*
3. *Pitch and Bank Action Plate*
4. *Universal Pedestal*
5. *Altitude Compensator*
6. *Manifold Pressure Regulating Bellows*
7. *Leveling Device Crank*
8. *Tachometer Regulator Bellows*
9. *Tachometer Pressure Regulating Spring*
10. *Rudder Pedal*
11. *Control Column*
12. *Throttle*
13. *Propeller Pitch Control*
14. *Rough Air Flexible Cable*
15. *Leveling Device Worm Gear*
16. *Leveling Device Cable Drum Shaft*
17. *Leveling Device Cable Plate*
18. *Throttle Bellows Mounting Plate*

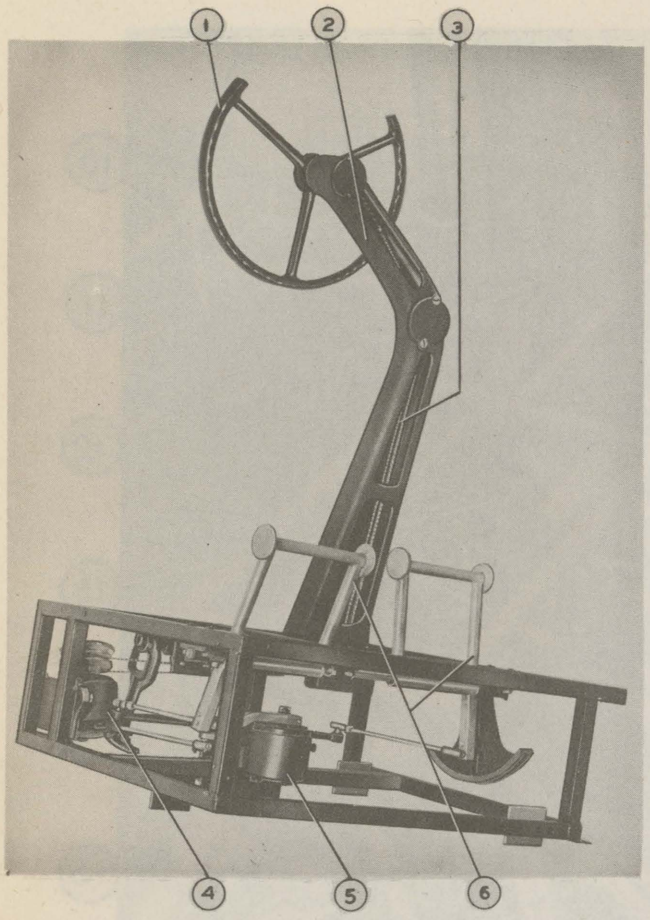

Figure 31—Pilot's Control Assembly—Complete View

1. *Pilot's Control Wheel*
2. *Control Column*
3. *Aileron Control Cables*
4. *Aileron Slip-stream Simulator*
5. *Elevator Slip-stream Simulator*
6. *Rudder Pedals*

(2) SLIP-STREAM SIMULATORS. (*See figure* 32.)

(*a*) There are three slip-stream simulators: one linked to the rudder bar, another to the wheel, and a third to the elevator control, and designed to load these controls to simulate the stiffening effect caused by air passing over the control surface of an airplane in flight.

(*b*) The body of the unit contains valves, mounted on a large shaft, operating in a fluid-filled compartment. The fluid flows from one side of each valve to the other, through a controllable valve which can be adjusted to furnish the desired resistance to elevator, aileron, or rudder control movement. A large shaft protrudes from the center of the unit to which a lever arm is attached. The lever arm is connected by a link rod to the control. A rectangular-head resistance-adjusting nut is located on the end of the shaft, with an ear on one side bent over to form a pointer. A hex nut, between the adjusting nut and lever arm, holds a packing in place to prevent leakage around the valve shaft.

(3) THE ROUGH AIR ASSEMBLY. (*See figure* 33.)—The rough air assembly consists of a motor drive, reduction gear, cam shaft, cams and flapper-type valves mounted upon a wood frame. The motor is a 50–60 cycle 4-watt 115-volt synchronous motor rated at 2000 rpm on 50-cycle current and 2400 rpm on 60-cycle current. The reduction gear is 600 to 1, turning the cam shaft at 4 rpm. The valves admit air to the turning motor and bellows vacuum lines, causing the Trainer to perform in an unstable and erratic manner, thus simulating conditions found in actual flight.

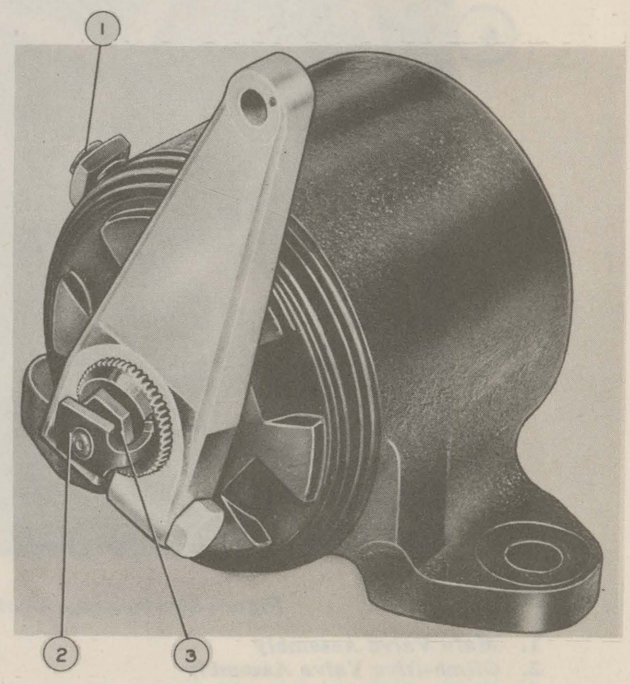

Figure 32—Slip-stream Simulator

1. *Filler Plug*
2. *Resistance Adjustment*
3. *Packing Nut*

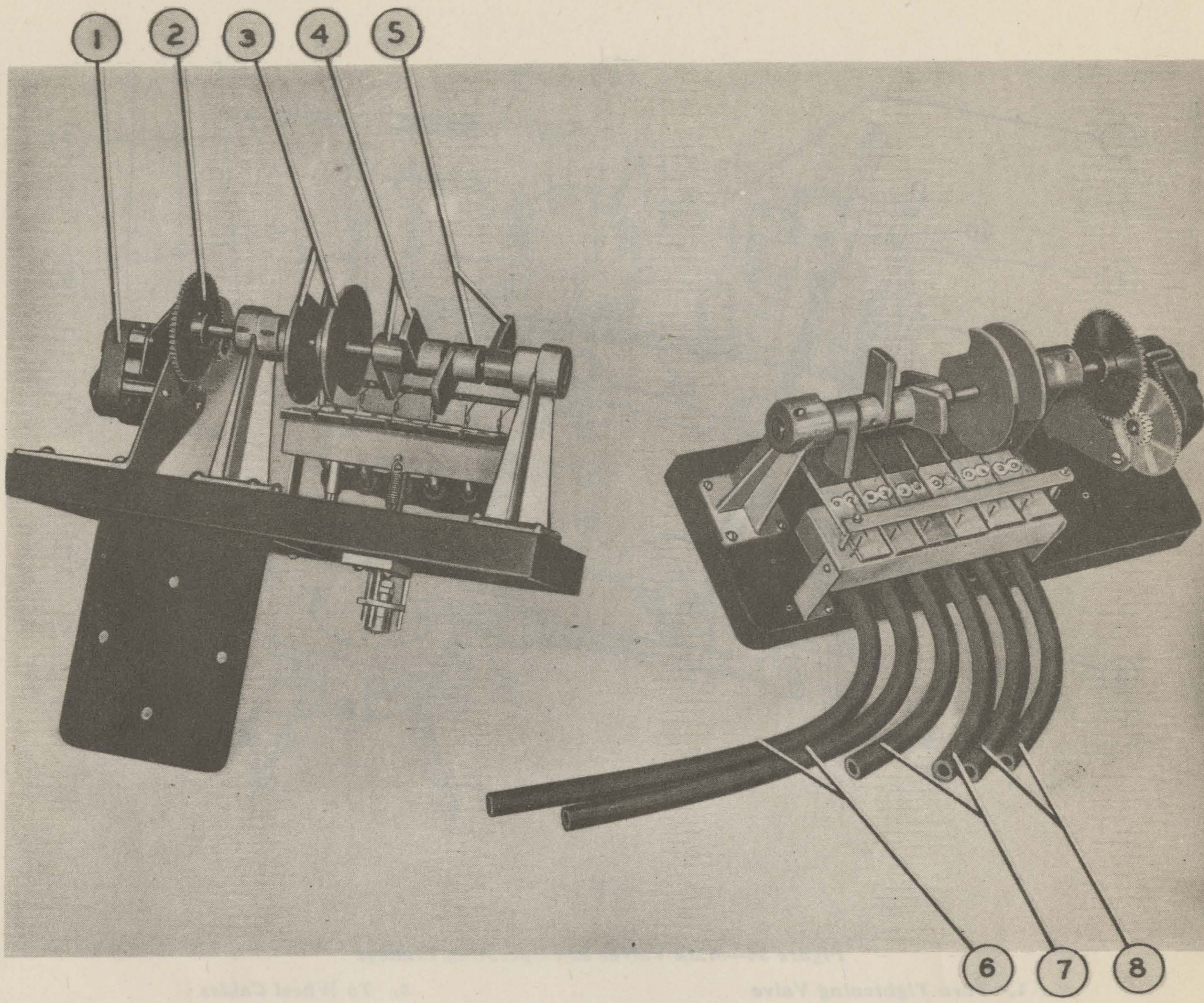

Figure 33—Rough Air Generator

1. *Rough Air Motor*
2. *Rough Air Gear Train*
3. *Rough Air Cam—Aileron Valve*
4. *Rough Air Cam—Elevator Valve*
5. *Rough Air Cam—Rudder Valve*
6. *Rough Air Atmosphere Vents—Rudder Valve*
7. *Rough Air Atmosphere Vents—Elevator Valve*
8. *Rough Air Atmosphere Vents—Aileron Valve*

(4) BANK ACTION ASSEMBLY. (*See figures* 28 *and* 34.)

(*a*) The bank action assembly in the Trainer is a mechanism which combines the movements of rudder and aileron control to simulate normal action of an airplane. When right or left aileron control is applied to an airplane in straight and level flight, the tendency of the airplane is to turn to the right or left respectively. In similar manner if right or left rudder is used the airplane will tend to bank in the direction of the turn.

(*b*) The bank action assembly consists of a series of linkages, bell cranks, and walking beams, interconnecting the rudder and aileron controls so movement of one will give proportional movement of the other, plus a linkage that applies the motion caused by change of attitude of the Trainer.

(*c*) The rudder control is transmitted to the rudder valve through the following linkage: link rod (C, figure 28) from rudder bar to bell crank (D, figure 34) adjustable linkage rod (Z) to walking beam (E), walking beam (E) to spring loaded link rod (F) to rudder valve, and spring loaded

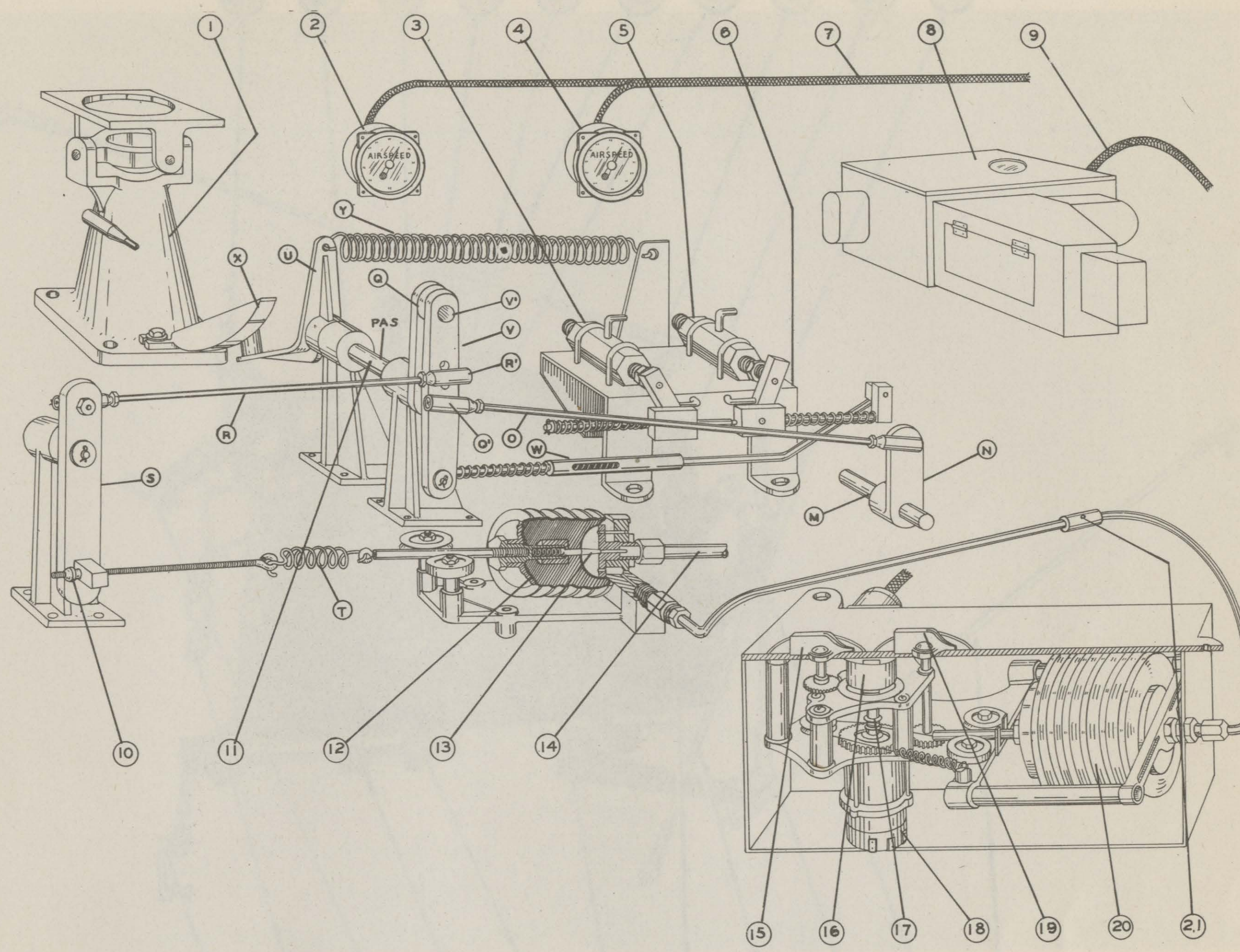

Figure 35—Air-Speed System and Pitch Action Assembly (Schematic)

1. *Universal Pedestal*
2. *Navigator's Panel*
3. *Dive Valve*
4. *Pilot's Panel*
5. *Climb Valve*
6. *Climb-Dive Valve Assembly*
7. *Telegon Transmitter Cable*
8. *Wind Drift Assembly*
9. *Teletorque Transmitter Cable*
10. *Knurled Nut*
11. *Pitch Action Shaft*
12. *Air-Speed Regulating Bellows*
13. *Needle Valve*
14. *Vacuum Supply Line*
15. *Indicated Air-Speed Adjusting Knob*
16. *Telegon Transmitter*
17. *Magnetic Coupling*
18. *Teletorque Transmitter*
19. *True Air-Speed Adjusting Knob*
20. *Air-Speed Transmitter Bellows*
21. *.020 Bleed Hole*

valve to open with an indication of loss of altitude and an increase in air speed. The pitch action assembly consists of a shaft mounted below the lateral axis of the fuselage with a U-shaped casting on the end toward the universal pedestal (figure 35). A roller on the tip of the casting operates against a curved stop that is mounted on the universal pedestal base. The roller is held against the stop by the spring (Y). A bell crank (Q) is pinned to the other end of the pitch action shaft. The walking beam (V) on the bell crank provides linkage to the throttle through link rod (O) to the climb-dive valves through (W) and to the air-speed regulator through reversing lever (S).

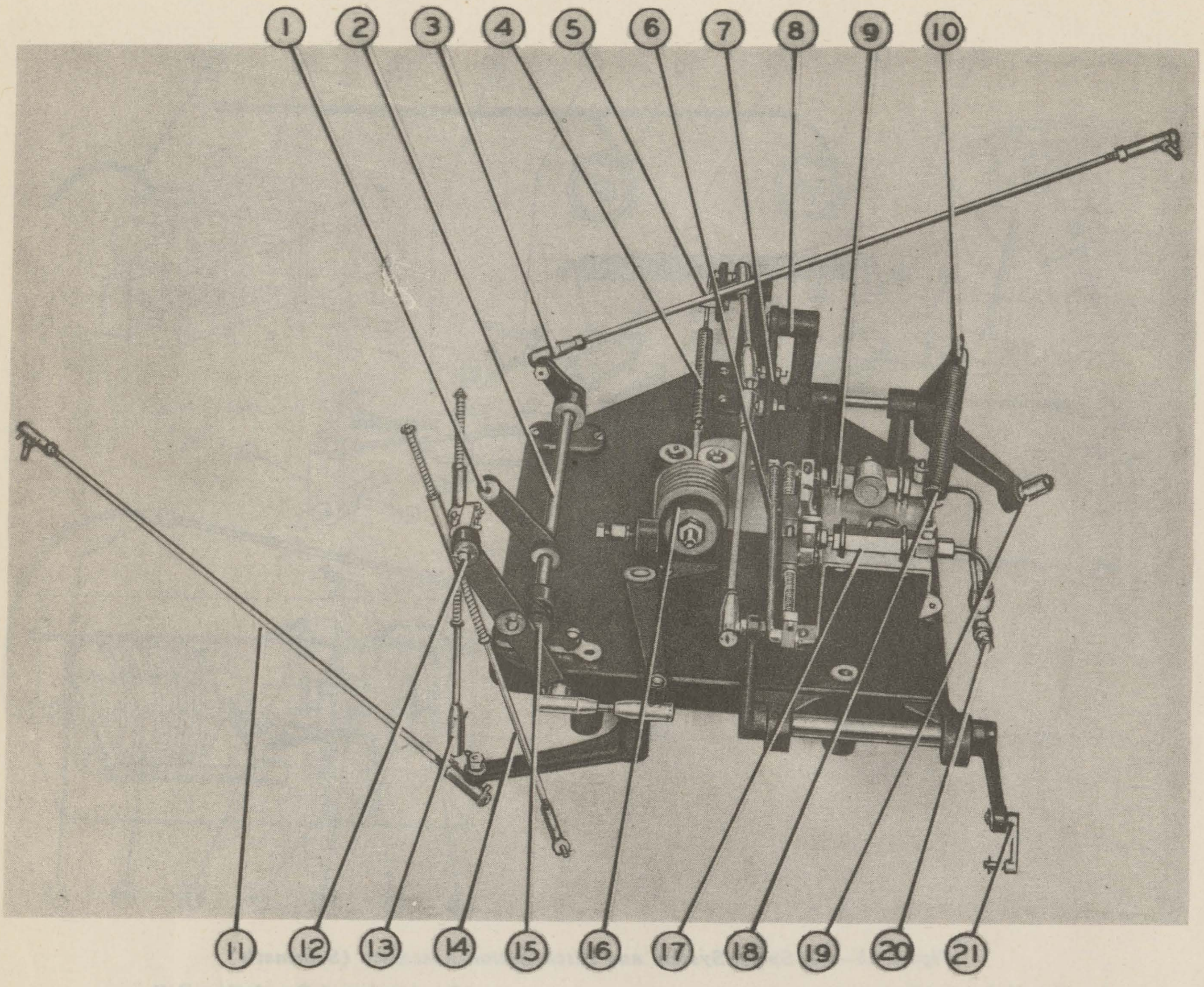

Figure 36—Pitch and Bank Action Plate

1. *Turn Tightener Lever Arm*
2. *Bank Action Shaft*
3. *Bank Action Bell Crank*
4. *Air-Speed Regulator Spring*
5. *Knurled Nut-Air Speed Spring*
6. *Climb-Dive Valve Compensator Rod*
7. *Pitch Action Walking Beam*
8. *Bell Crank*
9. *Dive Valve*
10. *Coupling Lever*
11. *Rudder Pedal Link Rod*
12. *Bank Action Walking Beam*
13. *Rudder Valve Compensator Rod*
14. *Automatic Bank Shaft Compensator Rod*
15. *Bank Action Shaft Bell Crank*
16. *Air-Speed Regulator Bellows*
17. *Climb Valve*
18. *Coupling Lever Spring*
19. *Coupling Lever Guide Roller*
20. *Climb-Dive Valve Manifold*
21. *Pitch Action Lever Arm Crank*

f. MAIN VALVES.

(1) AILERON VALVE. (*See figure* 37.)—The control wheel operates a cable drive which terminates on a pulley. This pulley is mounted on the extended shaft of the aileron slip-stream simulator, and on the upper end of this shaft is mounted a plate and lever. The function of this lever is to transmit motion to the aileron valve through a walking beam and linkage. The vacuum is supplied through the center section of the valve from the manifold, through (B) ports to port (3) in top section of the valve. In the neutral position this port

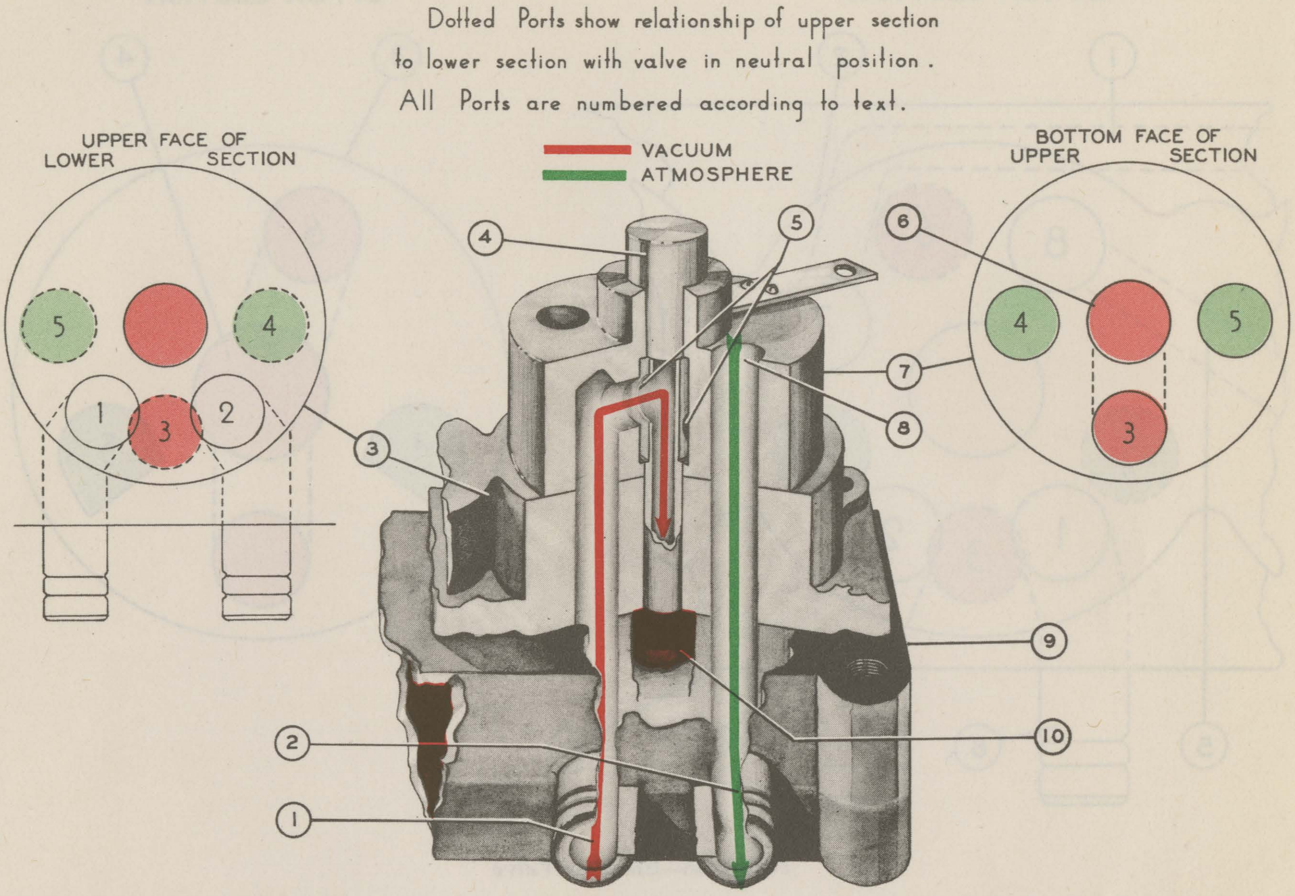

Figure 37—Aileron (Banking) Valve

1. *Lead to Left Banking Bellows*
2. *Lead to Right Banking Bellows*
3. *Lower Section (Manifold Head)*
4. *Valve Spindle*
5. *"B" Ports*
6. *Vacuum from Manifold*
7. *Upper Section*
8. *Atmosphere*
9. *Manifold Section*
10. *Vacuum Supply*

is between and slightly overlapping ports (1) and (2) in the lower section, allowing a small amount of vacuum to be applied to both banking bellows, exerting an equal downward pull on each side of the fuselage. Movement of the wheel to the left causes plate (S, figure 28) and attached lever to move link (R) to the left, causing lever (L, figure 34) to pivot at point (L′) and through it movement of link (W) to the right, rotating top leaf of aileron valve clockwise. (All references to the linkage drawing consider the point of view of the observer as being on the right side of the fuselage and slightly to the rear. All references to clockwise or counterclockwise valve movements are considered as observed from above and from the rear.) This movement brings port (3) over port (1), and applies vacuum to left banking bellows; and moves port (4) over port (2), allowing atmospheric pressure to enter right banking bellows, and a turn to the left results.

(2) ELEVATOR VALVE. (*See figure* 38.)—This valve is of the same basic design as the other main valves, and controls the supply of vacuum and atmospheric pressure to the pitching bellows, causing the Trainer to nose up or nose down. The

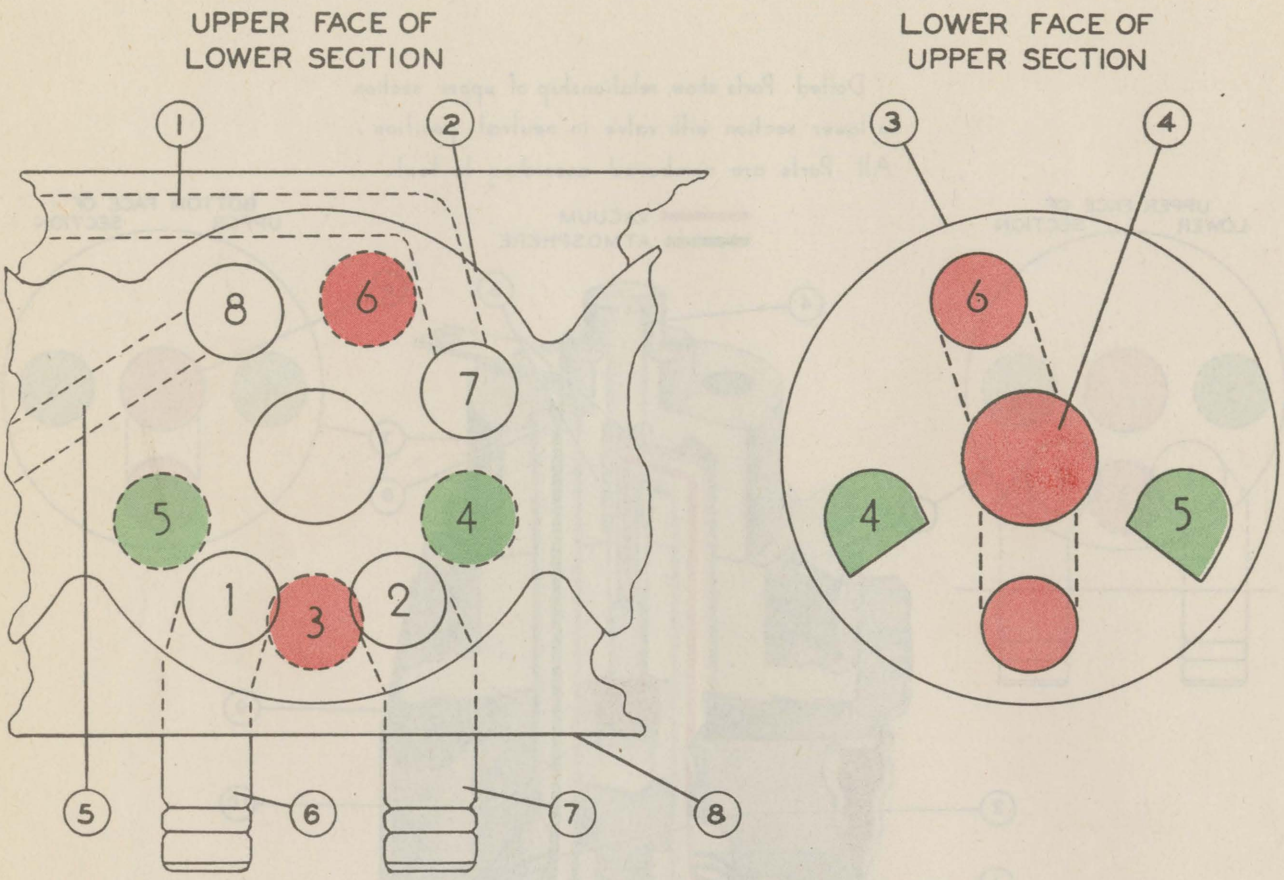

Figure 38—Elevator Valve

1. *Channel in Manifold to Turn Tightening Valve Upper Section*
2. *Lower Section*
3. *Upper Section*
4. *Vacuum Supply*
5. *Channel in Head to Turn Tightening Valve Spindle*
6. *Lead to Front Pitching Bellows*
7. *Lead to Rear Pitching Bellows*
8. *Manifold Section*

action of the top section of this valve is derived from the control column and connecting linkage. Vacuum is supplied from the manifold through the center section of the valve to ports (3) and (6) of the top section. When the column is pushed forward, link (T, figure 34) moves forward and rotates the upper section of the elevator valve in a clockwise manner. This motion moves vacuum supply port (3) over port (1), and through port (1) to the front pitching bellows; the valve motion also moves port (4) over port (2) and admits atmosphere to the rear bellows. The result of these applications of pressure is to tip the Trainer forward, or to "nose down." When the control column is in neutral position both ports (1) and (2) are slightly exposed to vacuum from port (3). This results in an equal amount of pressure being applied to both pitching bellows, and a level attitude of the Trainer is maintained. Automatic nose down with turn [section III, par. 2*g*(3)] is supplied through channels in the valve manifold and head to the output hoses of the elevator valve.

(3) RUDDER VALVE. (*See figure* 39.)—The rudder valve is operated by linkage from the rudder bar. When rudder is applied, the top leaf of the valve rotates. The rudder valve is similar in general construction to the aileron valve, with the addition of auxiliary ports to simulate automatic nose down with turn. For example: When left rudder is applied link (A) is forced back (figure 28) pivoting arm (B), thus pushing link (C) back (fig-

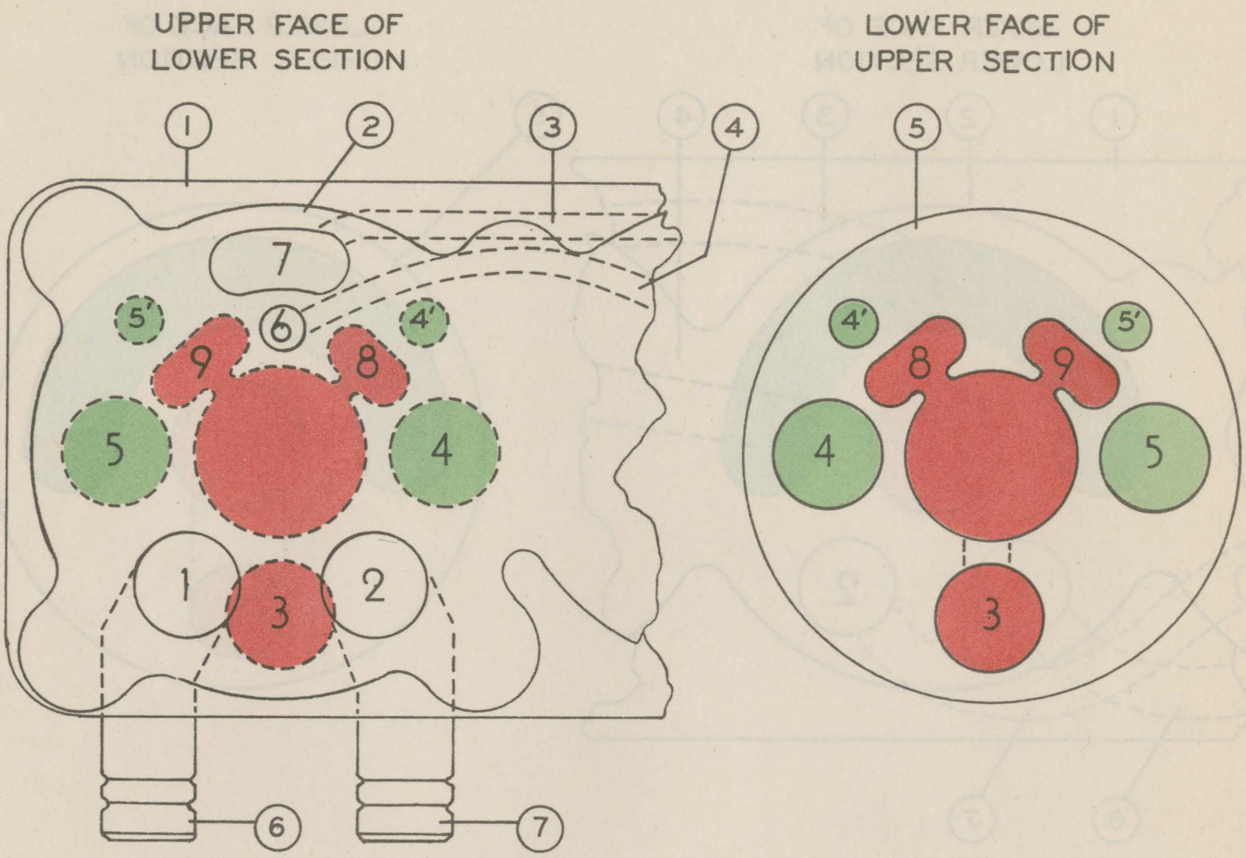

Figure 39—Rudder Valve—Automatic Nose Drop Type

1. *Manifold Section*
2. *Lower Section*
3. *Channel in Head Supplying Atmosphere to Rear Pitching Bellows*
4. *Channel in Manifold Supplying Vacuum to Front Pitching Bellows*
5. *Upper Section*
6. *Lead to Left Bank of Turning Motors*
7. *Lead to Right Bank of Turning Motors*

ure 34). Bell crank (D) turns counterclockwise which by means of a connecting link causes walking beam (E) to turn counterclockwise, pushing link (F) to the left, and rotating upper leaf of the rudder valve clockwise. This places vacuum port (3) over port (1) in lower section of valve, thus applying vacuum to the left turning motor. The same movement places atmosphere supply port (4) over port (2) and opens the right turning motor line to atmosphere. When the upper section of the rudder valve is neutral, port (3) is located centrally between ports (1) and (2) and slightly overlaps both, thus supplying a small amount of vacuum to both banks of the turning motor and maintaining a constant Trainer heading.

(4) TURN TIGHTENING VALVE. (*See figure* 40.)—The turn tightening valve, unlike the other valves, receives no direct supply of vacuum or atmosphere. It is supplied from auxiliary ports of the elevator valve, and its outlet ports supply additional vacuum and atmosphere to the turning motor by being interconnected with the outlet hoses from the rudder valve. The linkage to the turn tightening valve movable portion is attached directly to a lever on the shaft of the bank action assembly. When the control column is moved back to correct for automatic nose-down in a turn, vacuum is applied from auxiliary ports in the elevator valve through a channel in the manifold head to the center of the turn tightening valve to provide

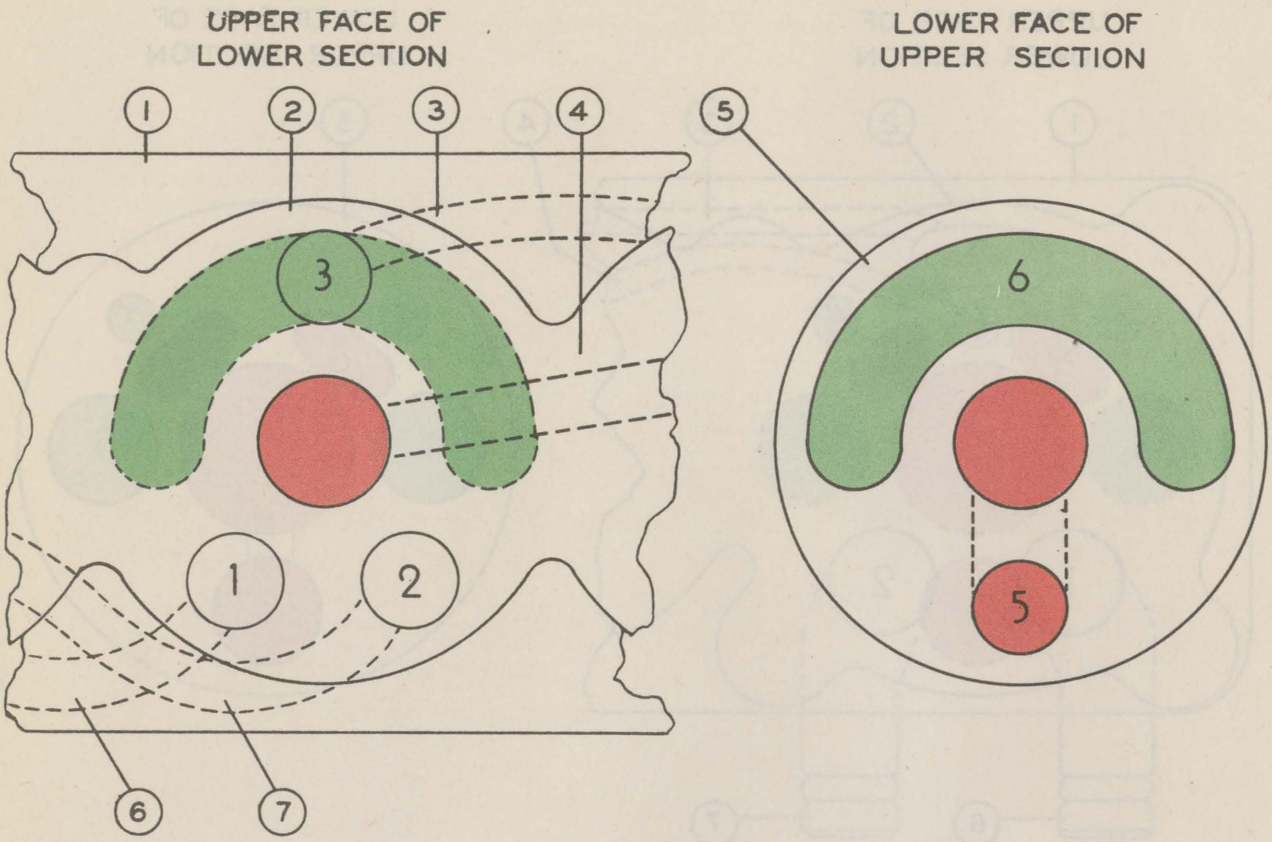

Figure 40—Turn Tightening Valve

1. *Manifold*
2. *Lower Section (Head)*
3. *Channel in Manifold Supplying Atmosphere from Elevator Valve to Turn Tightening Valve Lower Section*
4. *Channel in Head Supplying Vacuum to Turn Tightening Valve Spindle*
5. *Upper Section*
6. *Channel in Manifold to Left Turning Motor*
7. *Channel in Head to Right Turning Motor*

additional vacuum to the turning motor in operation. At the same time, the turning motor that is idling has a larger vent to atmosphere through the turn tightening valve.

g. AUTOMATIC FEATURES.

(1) AUTOMATIC TURN WITH BANK. (*See figures* 34 *and* 41.)—An airplane will turn when aileron control is applied and the ship banks, even though no rudder is applied. This action is simulated in the Trainer by interconnecting the rudder valve walking beam assembly and the bank action shaft. A specific example of automatic turn with bank: If the Trainer is banked to the left the link (P), attached to the bottom section of the Trainer universal joint, is pulled to the left pulling bottom of bell crank (O) to the left, and revolving shaft (V) clockwise, and bell crank (N) in same direction. Attached to the lower end of bell crank (N) is a rod which forms a center pivot for walking beam (E). Walking beam (E) now pivots at its lower end, since no rudder action has been applied, and the action is carried upward to pull link (F) to the left, thus giving the rudder valve upper leaf clockwise rotation with resultant left turn. At the same time rod (G) is also pulled toward the left, causing bell crank (H), shaft (J), and bell crank (K) to be rotated counterclockwise, and through differential action causes top of walking beam (L) to move still further to the right. This action is carried through link (W) to cause the aileron valve to rotate clockwise still further, resulting in in-

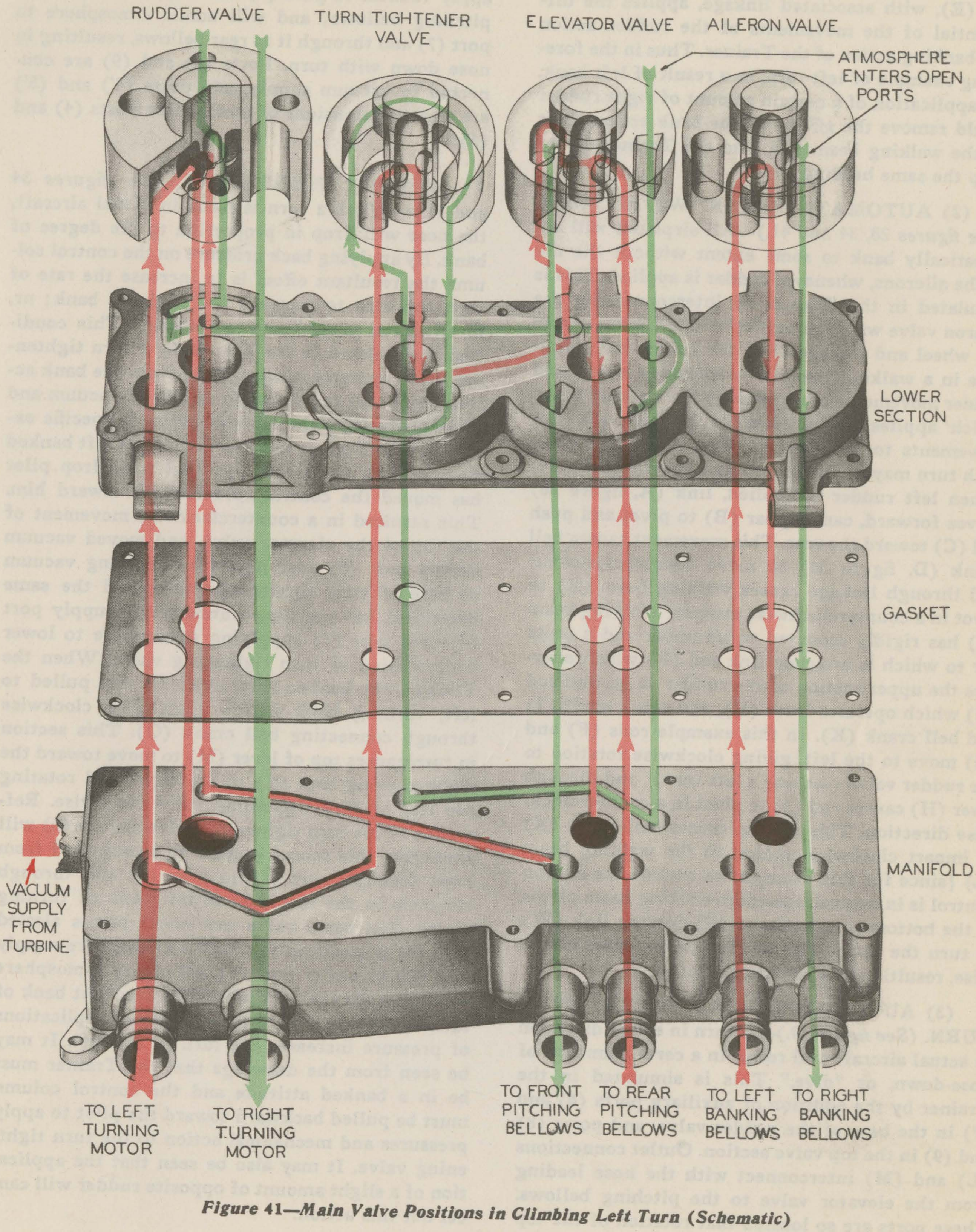

Figure 41—Main Valve Positions in Climbing Left Turn (Schematic)

creased bank to the left. The walking beam assembly (E), with associated linkage, applies the differential of the movements of the rudder action and banking action of the Trainer. Thus in the foregoing example of left turn, as a result of left bank, the application of a certain amount of right rudder would remove the effects of the bank action shaft on the walking beam (E), and the Trainer would keep the same heading.

(2) AUTOMATIC BANK WITH TURN. (*See figures* 28, 34 *and* 41.)—All airplanes will automatically bank to some extent without the aid of the ailerons, whenever rudder is applied. This is simulated in the Trainer by interconnecting the aileron valve with the rudder action. Linkage from the wheel and linkage from the rudder bar terminate in a walking beam. The combined wheel and rudder movements are applied to the walking beam, which applies the differential between the two movements to the aileron valve. Automatic bank with turn may be illustrated by a specific example: When left rudder is applied, link (A, figure 28) moves forward, causing bar (B) to pivot and push rod (C) toward the rear. This movement causes bell crank (D, figure 34) to move counterclockwise, and through linkage causes walking beam (E) to pivot in a counterclockwise manner. Walking beam (E) has rigidly mounted to its upper end a cross bar to which is attached link rod (F) which operates the upper section of the rudder valve, and rod (G) which operates lever (H), and hence shaft (J) and bell crank (K). In this example rods (F) and (G) move to the left, giving clockwise rotation to the rudder valve (causing a left turn); and through lever (H) causes rod (J) to pivot in a counterclockwise direction. This motion causes bell crank (K) to impart clockwise motion to the walking beam (L) [since for this example we assume the aileron control is in neutral, therefore walking beam pivots at the bottom connection to (R) forcing link (W) to turn the upper leaf of the aileron valve clockwise, resulting in a bank to the left.]

(3) AUTOMATIC NOSE DOWN WITH TURN. (*See figure* 39.)—A turn in either direction in actual aircraft will result in a certain amount of nose-down, or "dive." This is simulated in the Trainer by the addition of auxiliary ports (6) and (7) in the base of the rudder valve, and ports (8) and (9) in the top valve section. Outlet connections (L) and (M) interconnect with the hose leading from the elevator valve to the pitching bellows. These ports are so located that rotation of the top leaf of the rudder valve in either direction will apply vacuum to port (6) and thence to the front pitching bellows; and will admit atmosphere to port (7) and through it to rear bellows, resulting in nose down with turn. Ports (8) and (9) are connected to vacuum supply, and ports (4') and (5') are slotted extensions of atmosphere ports (4) and (5).

(4) TURN TIGHTENING. (*See figures* 34 *and* 41.)—When a turn is made in actual aircraft, the nose will drop in proportion to the degree of bank. By applying back pressure on the control column the resultant effect is to increase the rate of turn and also to increase the angle of bank; or, in effect, to cause "turn tightening." This condition is simulated in the Trainer by a turn tightening valve operated mechanically from the bank action shaft, and receiving its supply of vacuum and atmosphere from the elevator valve. A specific example: The Trainer has been put into a left banked turn, and to counteract resultant nose drop pilot has moved the control column back toward him. This resulted in a counterclockwise movement of the top of the elevator valve, and moved vacuum supply port (6) over port (8) supplying vacuum to base of turn tightening valve; and the same movement has positioned atmosphere supply port (4) over port (7) supplying atmosphere to lower body section of turn tightening valve. When the Trainer was banked left, link (P) was pulled to left, turning bank action shaft (V) clockwise through connecting bell crank (O). This section in turn causes top of lever (M) to move toward the right, moving link (Y) to the right, and rotating top leaf of turn tightening valve clockwise. Reference to the turn tightening valve (figure 40) will show that this causes vacuum to be supplied from base, through port (5) to port (1) and through channels in the manifold to left bank of turning motor. The same valve movement places slotted port (6) in position to connect atmosphere supply port (3) to outlet port (1), supplying atmosphere through a channel in the head to the right bank of turning motors. The resultant of these applications of pressure increases the turn to the left. It may be seen from the drawings that the Trainer must be in a banked attitude and the control column must be pulled backward toward the pilot to apply pressures and mechanical action to the turn tightening valve. It may also be seen that the application of a slight amount of opposite rudder will cancel out this action.

h. INSTRUMENT SYSTEMS.

(1) ALTITUDE SYSTEM.

(*a*) UNITS AND LINKAGE.—The altitude system is a system of mechanical linkages, operated by throttle action or fuselage attitude, that controls the climb-dive valves. The climb valve controls the vacuum applied to the altitude tank and the dive valve controls the atmosphere allowed to bleed back into the altitude tank. A differential pressure regulator is connected across the climb-dive valves to limit the rate of change in the tank by maintaining a constant 2 inches Hg to 2.5 inches Hg differential. The altimeter measures the difference between the outside atmospheric pressure and the partially evacuated altitude tank and indicates feet of altitude. The vertical speed indicator registers the rate of change of pressure in the altitude tank to indicate the rate of climb or dive. Vacuum for this system is supplied by the altitude pump on the counterbalance frame. [See section III, par. 3*e*(6).]

(*b*) CLIMB-DIVE VALVE ASSEMBLY (*figure* 42).

1. The climb-dive valve assembly consists of two separate valves mounted and controlled as a unit. Both valves are closed in the neutral or cruising position. Change of throttle setting and/or change in the nose-up or nose-down attitude of the

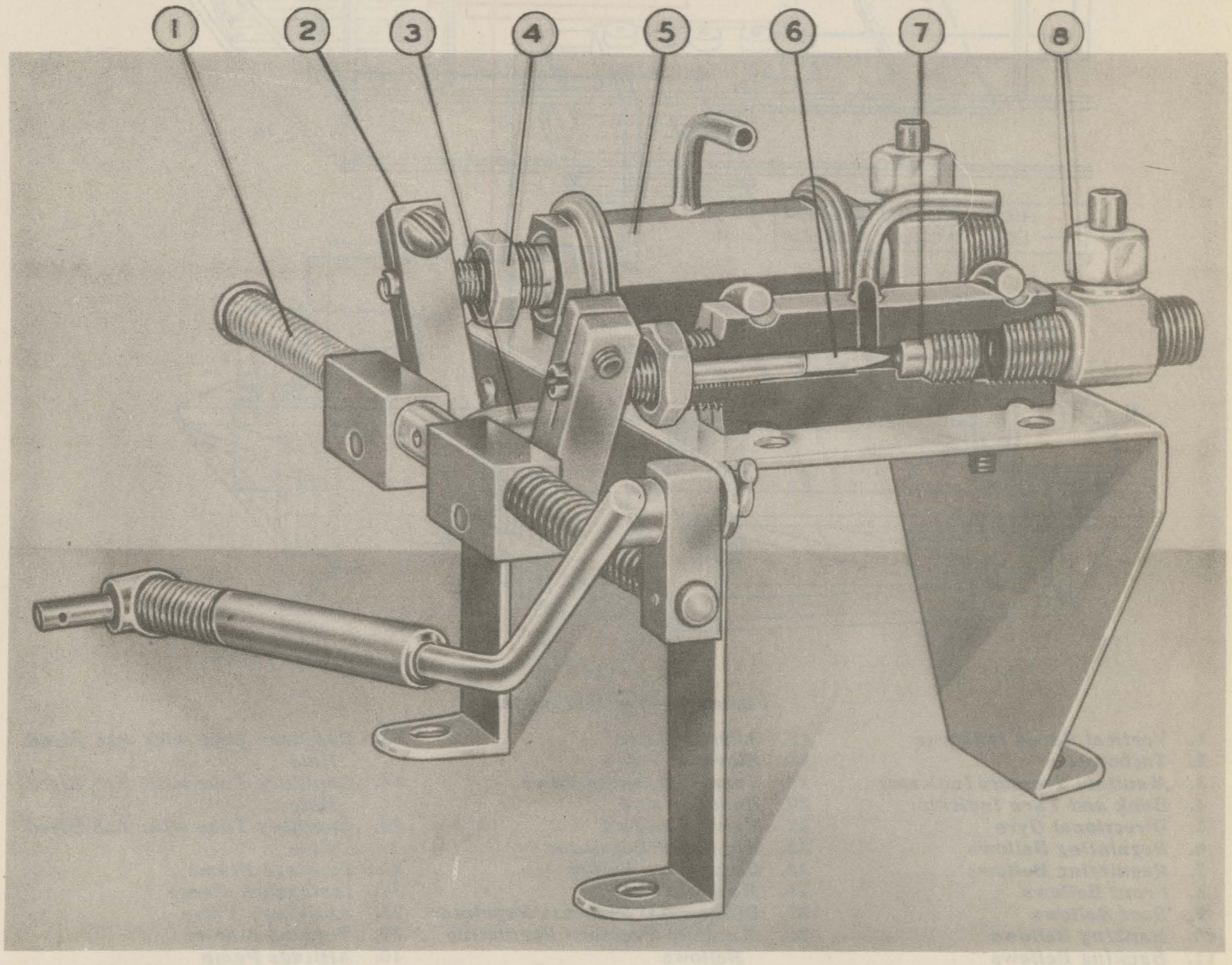

Figure 42—Climb-Dive Valve Assembly

1. *Compensator Rod*
2. *Lever Arm*
3. *Stop*
4. *Clamp Nut*
5. *Dive Valve Assembly*
6. *Needle Valve*
7. *Valve Seat*
8. *Climb Limit Valve*

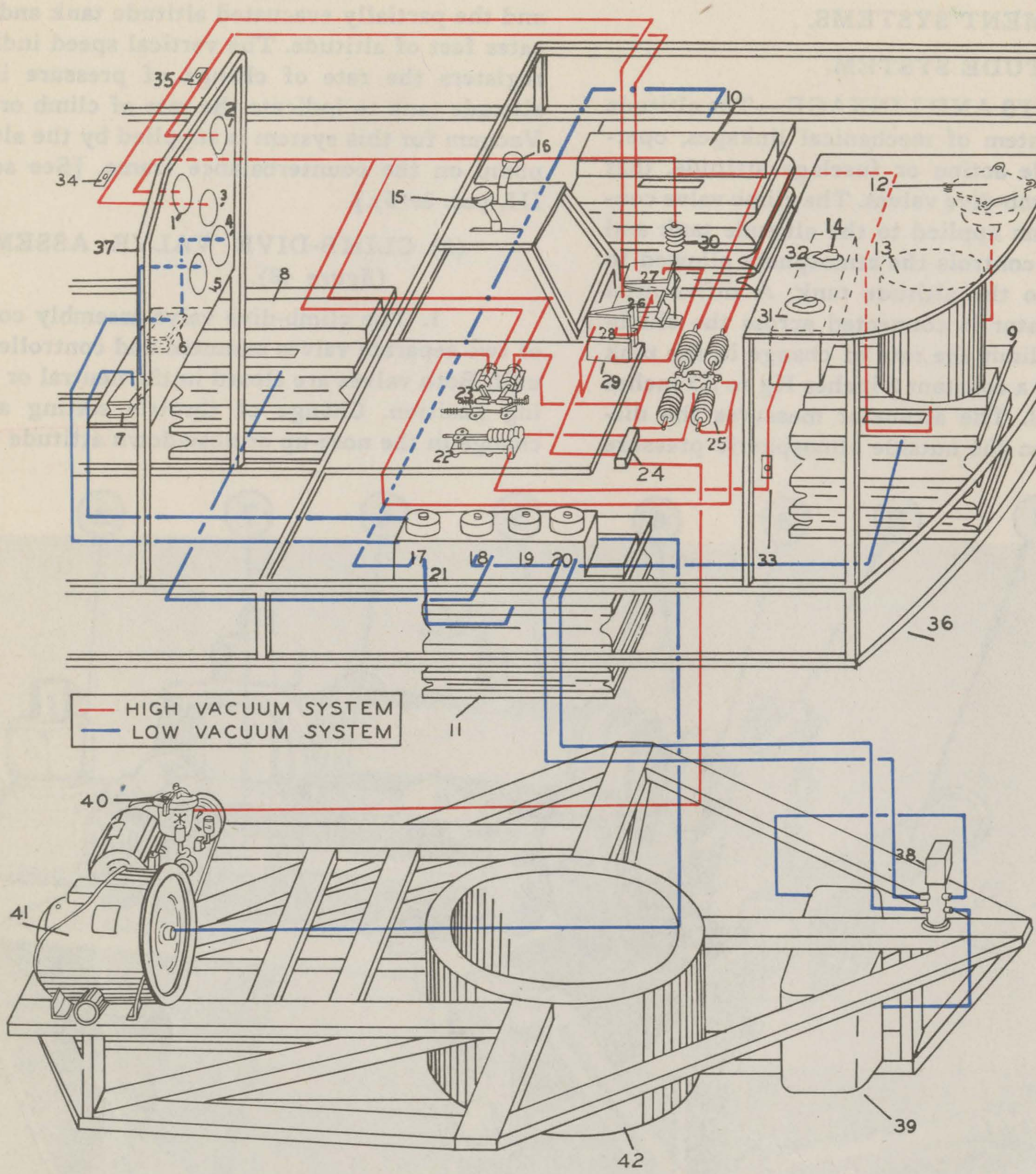

Figure 43—Vacuum System

1. *Vertical Speed Indicator*
2. *Tachometer*
3. *Manifold Pressure Indicator*
4. *Bank and Turn Indicator*
5. *Directional Gyro*
6. *Regulating Bellows*
7. *Regulating Bellows*
8. *Front Bellows*
9. *Rear Bellows*
10. *Banking Bellows*
11. *Banking Bellows*
12. *Altitude Transmitter*
13. *Altitude Tank*
14. *Air-Speed Transmitter*
15. *Throttle Lever*
16. *Constant-Speed Propeller Control Lever*
17. *Aileron Valve*
18. *Elevator Valve*
19. *Turn Tightening Valve*
20. *Rudder Valve*
21. *Valve Manifold*
22. *Air-Speed Regulator*
23. *Climb-Dive Valves*
24. *Manifold*
25. *Differential Pressure Regulator*
26. *Manifold Pressure Regulating Bellows*
27. *Tachometer Regulating Bellows*
28. *Limiting Regulator Bellows*
29. *Limiting Regulator Bellows*
30. *Altitude Compensator*
31. *Indicated Air-Speed Control*
32. *True Air-Speed Control*
33. *Capillary Tube with .025 Bleed Hole*
34. *Capillary Tube with .015 Bleed Hole*
35. *Capillary Tube with .025 Bleed Hole*
36. *Fuselage Frame*
37. *Instrument Panel*
38. *Anti-Turn Valve*
39. *Turning Motors*
40. *Altitude Pump*
41. *Turbine*
42. *Base Assembly*

Trainer will open either one valve or the other. When one valve opens, the other remains closed.

2. The climb valve controls vacuum applied to the altitude tank, and the dive valve controls the atmosphere permitted to flow back into the tank.

3. The needle assembly of the valve is composed of two parts, the needle proper and a sleeve into which the needle is silver-soldered. The needle is of small diameter for a portion of its length to give it flexibility, and thus self-centers itself in the valve seat. The sleeve is threaded and screws into the brass body of the valve. A clamp nut is provided to take up wear in the threads.

4. Adjustment of these valves is an exceedingly delicate operation and should be attempted only by a factory-trained man or an authorized repair base.

(*c*) ALTITUDE TANK.—The altitude tank (figure 43) is located under the radio operator's desk in the rear of the fuselage. It is cylindrical in shape and sealed at both ends. One of its functions is to allow for a greater lapse of time for a pressure change between the altimeter mechanism and the climb-dive valves. Without the altitude tank, the indicated changes in pressure (controlled by the climb-dive valves) would be almost instantaneous and therefore not characteristic of aircraft.

(*d*) DIFFERENTIAL PRESSURE REGULATOR. (*See figures* 44 *and* 45.)

1. DESCRIPTION.—The differential pressure regulator, located in the rear center of the fuselage underneath the floor, is a device which limits the rate of change of pressure to a certain maximum when climbing or diving. It accomplishes this by maintaining a constant pressure differential across the climb-dive valves. Any changes of pressure within the altitude tank cause the differential pressure regulator to react immediately. Thus, when the Trainer is in operation, the regulator is in a continual state of movement, and is probably never completely at rest.

2. RELIEF VALVE.—The altitude pump relief valve used in the Trainer is adjusted to supply a vacuum of approximately 14 inches Hg. It is evident, therefore, that if the climb valve was opened when the pressure in the altitude tank was near sea level, air would be withdrawn from the tank so rapidly, because of the high pressure differential, that damage to the altimeter and vertical speed indicator would result, and the indications would far exceed the capabilities of a representative aircraft. A similar condition would result if the Trainer was at a high "altitude" and the dive valve was opened. If no regulator were used, atmosphere would be drawn into the altitude tank at a high rate because of the large pressure differential, causing a sudden increase in pressure with accompanying excessive indications of dive, and resultant damage to the instruments. Because of these comparatively large pressure differentials, excessive vertical speed indications would result even if the climb or dive valve were opened only slightly.

3. REGULATOR.—The regulator, used to control this pressure differential, utilizes two-way slide valves controlled by an arrangement of bellows. The design is such that a constant differential across the climb and dive valves is always maintained during operation. This differential is adjustable across both the climb valve and the dive valve, and is usually set to about 2 inches Hg. The pressure differential regulator will not function efficiently unless at least 2 inches Hg difference in pressure exists across the valves. A lesser pressure differential causes the regulator to become sluggish, resulting in faulty instrument indications.

4. SLIDE VALVES.—There are two slide valves used, one controlling the differential across the climb valve, and the other across the dive valve. The slide valve rods are reduced in diameter at the center, and are connected at each end to identical metal bellows. Expansion and contraction of the bellows causes the valve rod to move back and forth within the valve body. The valve body contains three ports spaced in such a manner that movement of the slide valve will position the reduced diameter of the rod over the center port and also over one or the other of the end ports, thus allowing the passage of air through the valve. When the slide valve is centered, neither end port is uncovered and air passage is restricted. One end port of the climb regulator valve is vented to atmosphere, while the other end port is connected to the vacuum side of the altitude pump. The center port is connected to one of the bellows controlling the slide valve, and also to the climb valve. The opposing bellows is connected directly to the altitude tank. In the case of the dive regulator valve, one end port is connected to the exhaust side of the altitude pump rather than to atmosphere, while the other end port is connected to the vacuum side

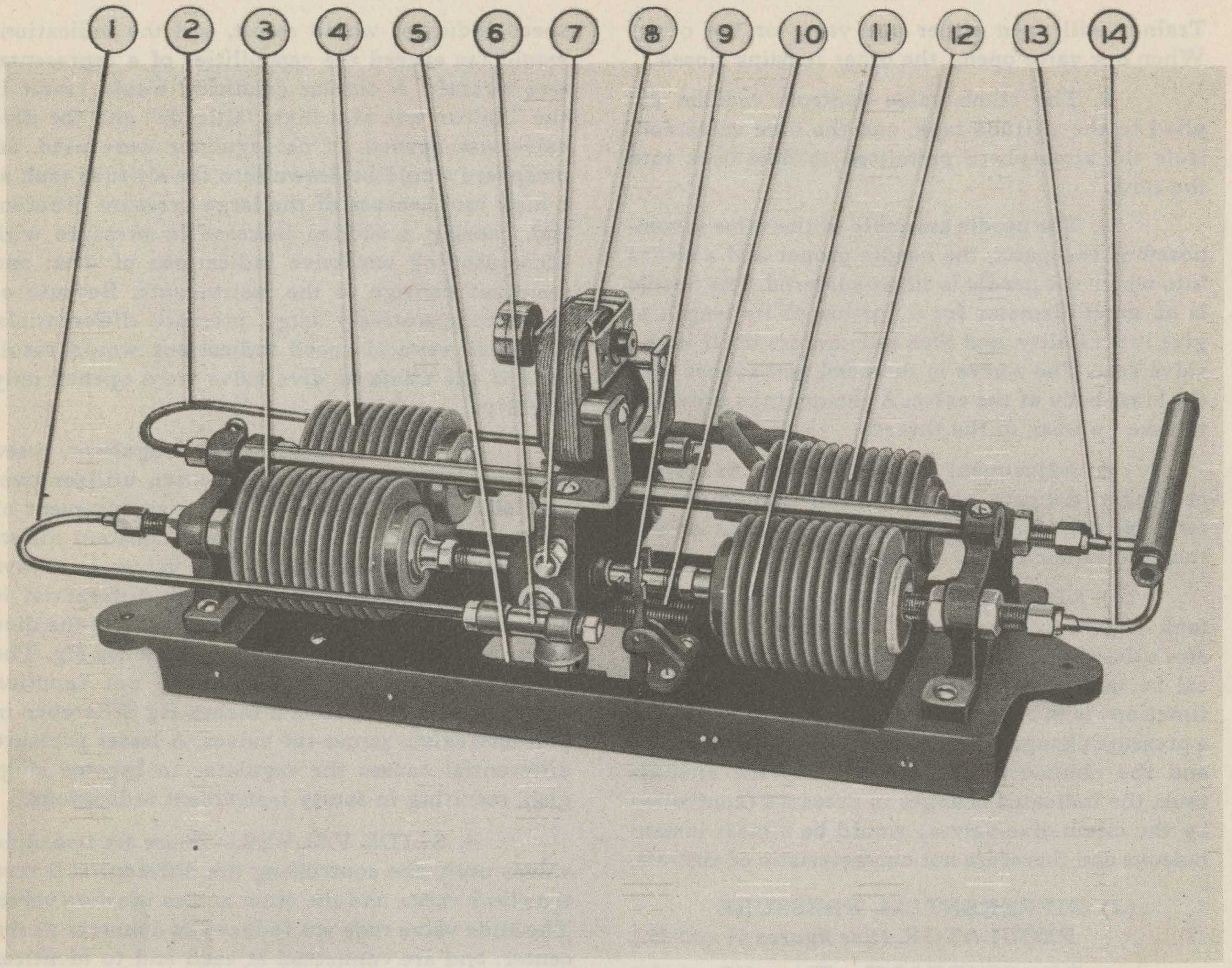

Figure 44—Differential Pressure Regulator

1. *Outlet Port—Climb Valve*
2. *Outlet Port—Dive Valve*
3. *Vacuum Pump Bellows—Climb*
4. *Vacuum Pump Bellows—Dive*
5. *Pump Bellows Spring—Climb*
6. *Outlet Port Manifold—Climb*
7. *Vacuum Port—Climb Valve*
8. *Vibrator Motor*
9. *Valve Stop*
10. *Pump Bellows Spring—Dive*
11. *Altitude Tank Bellows—Climb*
12. *Altitude Tank Bellows—Dive*
13. *Altitude Tank Outlet Port—Dive*
14. *Altitude Tank Outlet Port—Climb*

of the altitude pump. The center port is connected to one of the bellows controlling the slide valve, and also to the dive valve. The opposing bellows is connected directly to the altitude tank. Stops are provided to limit the travel of both slide valves, and tension springs have been added.

5. PRINCIPLE OF OPERATION.

a. It can be seen (figure 45) that when the slide valves are in the central (neutral) position, both the atmospheric and vacuum ports are closed, and hence a state of equilibrium exists in the sense that no air can flow through the valve body in any direction. The bellows (A) and (A′) are connected to the altitude tank side of the climb-dive valves while bellows (B) and (B′) are connected to the inlet side of these valves. If springs were not attached to the bellows, the slide valves would assume the neutral center position when the pressure in (A) and (B), and (A′) and (B′), was equal. Since (A) and (B), and (A′) and (B′), are connected to opposite sides of the climb-dive valves,

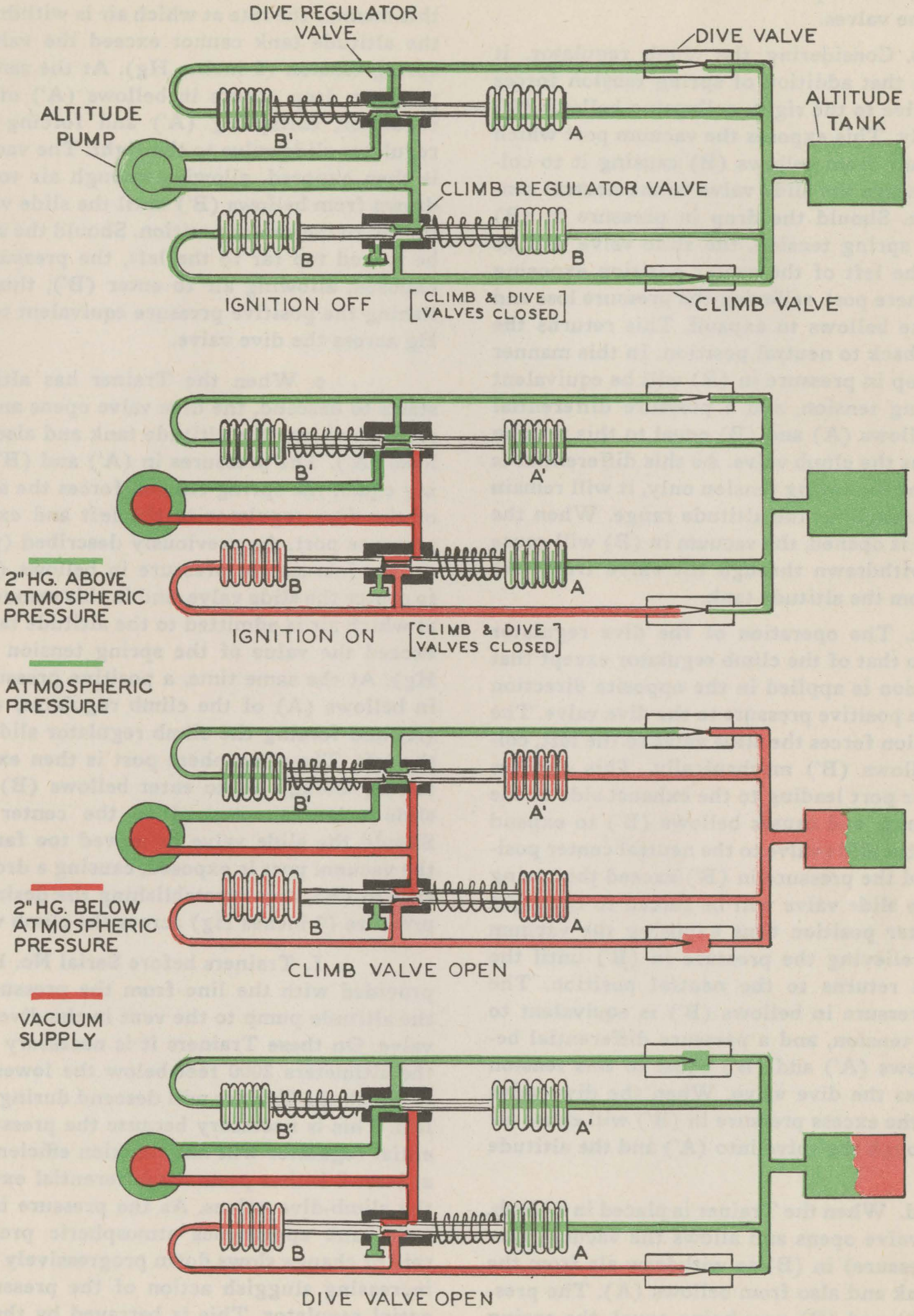

Figure 45—Differential Pressure Regulator in Various Positions (Schematic)

this condition would occur whenever either valve was opened, and no pressure differential would exist across the valves.

b. Considering the climb regulator, it can be seen that addition of spring tension forces the slide valve to the right, collapsing bellows (A) mechanically. This exposes the vacuum port which withdraws air from bellows (B) causing it to collapse and return the slide valve to the neutral center position. Should the drop in pressure in (B) exceed the spring tension, the slide valve will be moved to the left of the center position exposing the atmosphere port, relieving the pressure loss and allowing the bellows to expand. This returns the slide valve back to neutral position. In this manner the final drop in pressure in (B) will be equivalent to the spring tension, and a pressure differential between bellows (A) and (B) equal to this tension exists across the climb valve. As this differential is a function of the spring tension only, it will remain constant throughout the altitude range. When the climb valve is opened, the vacuum in (B) will cause air to be withdrawn through the valve from (A) and also from the altitude tank.

c. The operation of the dive regulator is similar to that of the climb regulator except that spring tension is applied in the opposite direction to provide a positive pressure to the dive valve. The spring tension forces the slide valve to the left, collapsing bellows (B′) mechanically. This exposes the pressure port leading to the exhaust side of the altitude pump, and causes bellows (B′) to expand and return the slide valve to the neutral center position. Should the pressure in (B′) exceed the spring tension, the slide valve will be forced to the right of the center position thus exposing the vacuum port, and relieving the pressure in (B′) until the slide valve returns to the neutral position. The ultimate pressure in bellows (B′) is equivalent to the spring tension, and a pressure differential between bellows (A′) and (B′) equal to this tension exists across the dive valve. When the dive valve is opened, the excess pressure in (B′) will cause air to flow through the valve into (A′) and the altitude tank.

d. When the Trainer is placed in a climb, the climb valve opens and allows the vacuum (decreased pressure) in (B) to withdraw air from the altitude tank and also from bellows (A). The pressures in (A) and (B) now being equal, the spring tension forces the slide valve to the right and exposes the vacuum port. As previously described (paragraph b), the consequent drop in pressure in bellows (B) tends to center the slide valve, and in this manner the rate at which air is withdrawn from the altitude tank cannot exceed the value of the spring tension (2 inches Hg). At the same time, a pressure drop occurs in bellows (A′) of the dive regulator, collapsing (A′) and forcing the dive regulator slide valve to the right. The vacuum port is then exposed, allowing enough air to be withdrawn from bellows (B′) until the slide valve is returned to the center position. Should the slide valve be moved too far to the left, the pressure port is exposed, allowing air to enter (B′), thus reestablishing the positive pressure equivalent to 2 inches Hg across the dive valve.

e. When the Trainer has altitude and starts to descend, the dive valve opens and permits air to flow into the altitude tank and also into bellows (A′). The pressures in (A′) and (B′) now being equal, the spring tension forces the slide valve of the dive regulator to the left and exposes the pressure port. As previously described (paragraph c), the increase in pressure in bellows (B′) tends to center the slide valve, and in this manner the rate at which air is admitted to the altitude tank cannot exceed the value of the spring tension (2 inches Hg). At the same time, a positive pressure occurs in bellows (A) of the climb regulator, expanding (A) and forcing the climb regulator slide valve to the left. The atmosphere port is then exposed, allowing enough air to enter bellows (B) until the slide valve is returned to the center position. Should the slide valve be moved too far to right, the vacuum port is exposed, causing a drop in pressure in (B), thus reestablishing the desired loss of pressure (2 inches Hg) across the climb valve.

f. Trainers before Serial No. 107 are not provided with the line from the pressure side of the altitude pump to the vent in the dive regulator valve. On these Trainers it is necessary to pre-set the altimeters 2000 feet below the lowest altitude to which the Trainer will descend during any problem. This is necessary because the pressure differential regulator will not function efficiently unless at least 2 inches pressure differential exists across the climb-dive valves. As the pressure in the altitude tank approaches atmospheric pressure, the rate of change slows down progressively due to the increasing sluggish action of the pressure differential regulator. This is betrayed by the behavior of the vertical speed indicator during instrument let-downs and instrument landing problems. If the

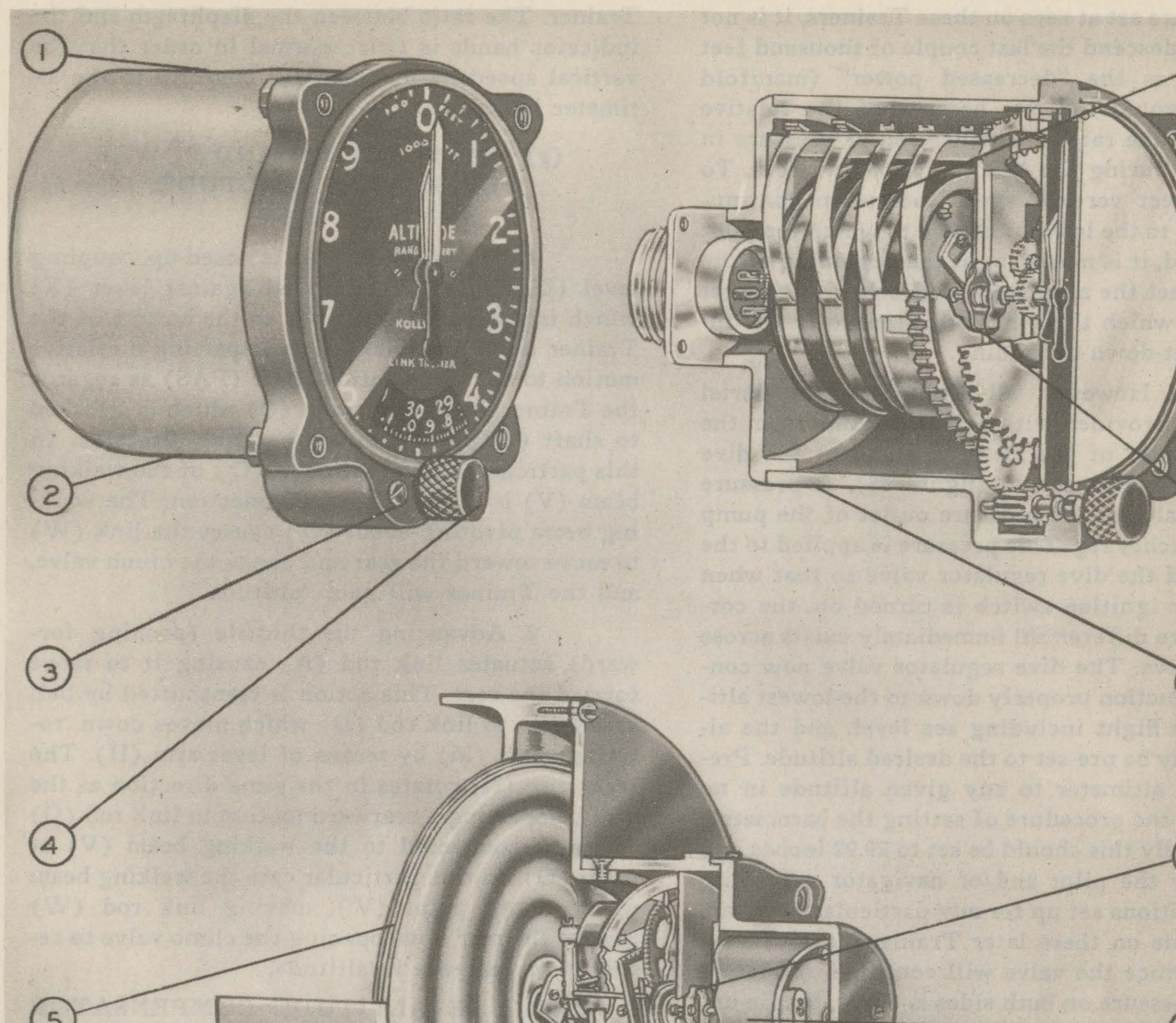

Figure 46—Altimeter

1. *Receiver Telegon (in case)*
2. *Case Located in Navigator's Instrument Panel*
3. *Locking Screw*
4. *Zero Setting Knob*
5. *Diaphragm (to Altitude Tank)*
6. *Case Mounted to Radio Table in Fuselage*
7. *Receiver Telegon*
8. *Magnetic Coupling*
9. *Case Located in Pilot's Instrument Panel*
10. *Magnetic Coupling*
11. *Transmitter Telegon*

altimeters are set at zero on these Trainers, it is not possible to descend the last couple of thousand feet as rapidly as the "decreased power" (manifold pressure) would indicate because of the relative slowness of the rate of equalization of pressure in the system during the last two thousand feet. To obtain correct vertical speed indication continuously down to the lowest altitude to which the pilot will descend, it is necessary at the beginning of the "flight" to set the altimeters well below the lowest altitude to which the pilot will descend in the instrument let-down or landing.

g. However, all Trainers after Serial No. 107 are provided with a pressure line from the pressure outlet of the altitude pump to the dive regulator valve as shown (figure 45). A pressure regulator valve at the pressure outlet of the pump is set to 2 inches Hg. This pressure is applied to the vent hole of the dive regulator valve so that when the Trainer ignition switch is turned on, the correct pressure differential immediately exists across the dive valve. The dive regulator valve now continues to function properly down to the lowest altitude of the flight including sea level, and the altimeters may be pre-set to the desired altitude. Pre-setting the altimeter to any given altitude in no way affects the procedure of setting the barometric scale. Initially this should be set to 29.92 inches and changed by the pilot and/or navigator according to the conditions set up for any particular problem. It is possible on these later Trainers to fly below sea level (since the valve will continue to operate until the pressure on both sides is equal, that is until the altitude tank is under 2 inches of positive pressure) but again the rate of pressure change in the altitude tank will become more and more sluggish as the pressures in (A′) and (B′) tend to equalize.

(*e*) ALTIMETER. (*See figure* 46.)—The altimeter is a Kollsman instrument adapted for use in the Trainer. The linkage between the diaphragm and the transmitter telegon (located under the radio operator's desk) is fixed at twice the normal ratio. This means that only half the normal reduction in pressure is required for the altimeter to indicate a given altitude. The indicator is actuated by means of a receiver telegon. The outward appearance of the indicator is identical with that used in present day aircraft.

(*f*) VERTICAL SPEED INDICATOR (*figure* 47).—The vertical speed indicator is a Kollsman instrument adapted for use in the Trainer. The ratio between the diaphragm and the indicator hands is twice normal in order that the vertical speed indications will conform to the altimeter indications.

(*g*) PITCH ACTION AND POWER EFFECT ON ALTITUDE. (*See figures* 35 *and* 48.)

1. When the Trainer is nosed up, coupling level (U, figure 35) is moved against lever (X) which is stationary (mounted to the bottom of the Trainer universal joint), thus imparting a relative motion to the pitch action shaft (PAS) as regards the Trainer floor. Bell crank (Q) which is attached to shaft (PAS) rotates in the same direction. In this particular case pivot point (O′) of the walking beam (V) is at the throttle connection. The walking beam pivoting about (O′) causes the link (W) to move toward the rear and opens the climb valve, and the Trainer will gain "altitude."

2. Advancing the throttle (pushing forward) actuates link rod (A) causing it to move toward the rear. This action is transmitted by bell crank (B) to link rod (D) which moves down, rotating shaft (M) by means of lever arm (H). The lever arm (N) rotates in the same direction as the shaft, imparting a rearward motion to link rod (O) which is connected to the walking beam (V) at point (O). In this particular case the walking beam pivots about point (V′), moving link rod (W) toward the rear, thus opening the climb valve to result in an increase in altitude.

(*h*) THE ALTITUDE COMPENSATOR (*figure* 48).—This unit is a sylphon bellows assembly in the altitude system. The sylphon is mechanically connected between the throttle linkage and the manifold pressure regulating bellows to simulate the effects of altitude on manifold pressure. As the altitude is increased, the altitude compensator bellows tends to collapse, shortening the linkage between the manifold pressure regulating bellows and the arm (F), thus showing a decrease in manifold pressure with increase in altitude.

(2) AIR-SPEED SYSTEM. (*See figure* 35.)

(*a*) GENERAL DESCRIPTION.

1. The principle of the air-speed system is similar to that of the manifold pressure system in that the instrument indications are ultimately dependent on a change of pressure. Change in engine power output or pitching motion of Trainer affects the air-speed reversing arm, which through a regu-

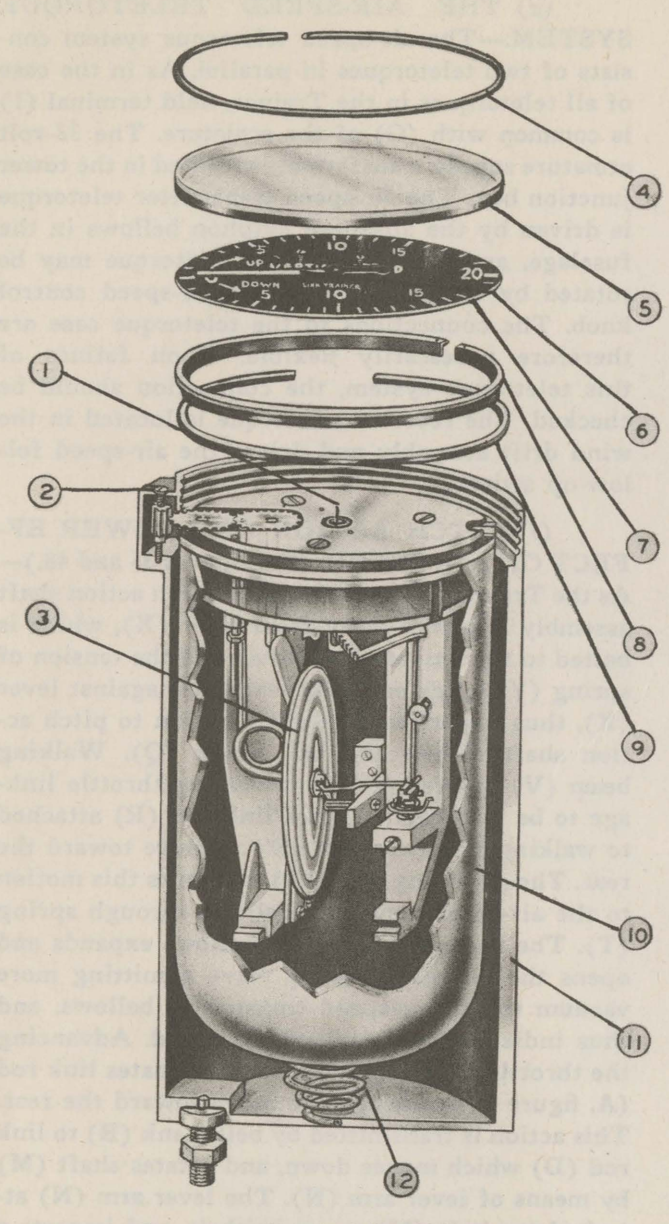

Figure 47—Vertical Speed Indicator

1. *Hand Staff*
2. *Zero Setting Screw*
3. *Diaphragm*
4. *Snap Ring*
5. *Bezel*
6. *Hand*
7. *Dial*
8. *Ring*
9. *Brass Ring*
10. *Thermos Bottle*
11. *Case*
12. *Spring*

lator spring affects the needle valve of the air-speed regulator bellows which is connected on one side to the vacuum supply from the altitude pump, and on the other side to the bellows of the air-speed transmitter.

2. The air-speed system is partly mechanical and partly electrical. Within the air-speed transmitter box is a metal bellows, a teletorque, and a telegon unit.

3. The master air-speed teletorque controls a dependent teletorque on the wind drift mechanism case which in turn controls the air-speed component of the mechanical wind triangle. See wind drift mechanism for details. [See section III, par. 3*b*(3).]

4. The master telegon, which is coupled magnetically to the teletorque shaft, controls two units: one in the air-speed indicator on the pilot's panel, and the other in the air-speed indicator on the navigator's panel. Both telegon and teletorque are supplied with power from fuselage junction

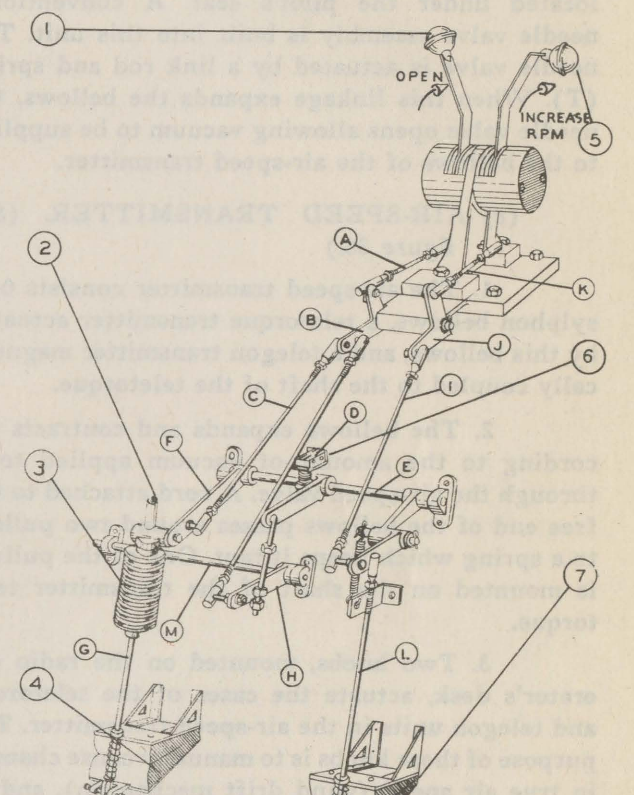

Figure 48—Engine and Propeller Pitch Control (Schematic)

1. *Throttle*
2. *To Altitude Tank*
3. *Altitude Compensator*
4. *Manifold Pressure Regulator Bellows*
5. *Propeller Control*
6. *Landing Gear Warning Switch*
7. *Tachometer Regulator Bellows*

box No. 3. The telegon oscillator is the source of power for the telegon.

5. The change in air-speed indications which result from changes in air density (pressure altitude-temperature error) are simulated in the Trainer and controlled by a knob. The changes in true air speed due to icing or load changes are controlled by a second knob. By rotating both knobs to the amount of change desired, the instructor rotates the fields of the transmitter telegon or the transmitter teletorque, reducing the indication on the air-speed indicators, and changing the true air speed as icing or load conditions change.

(*b*) AIR-SPEED REGULATOR BELLOWS. (*See figure* 35.)—The regulator bellows consists of a metal sylphon, mounted on a frame, located under the pilot's seat. A conventional needle valve assembly is built into this unit. The needle valve is actuated by a link rod and spring (T). When this linkage expands the bellows, the needle valve opens allowing vacuum to be supplied to the bellows of the air-speed transmitter.

(*c*) AIR-SPEED TRANSMITTER. (*See figure* 35.)

1. The air-speed transmitter consists of a sylphon bellows, a teletorque transmitter actuated by this bellows, and a telegon transmitter magnetically coupled to the shaft of the teletorque.

2. The bellows expands and contracts according to the amount of vacuum applied to it through the air-speed valve. A cord attached to the free end of the bellows passes around two pulleys to a spring which keeps it taut. One of the pulleys is mounted on the shaft of the transmitter teletorque.

3. Two knobs, mounted on the radio operator's desk, actuate the cases of the teletorque and telegon units in the air-speed transmitter. The purpose of these knobs is to manually cause changes in true air speed (wind drift mechanism), and in air-speed indications (air-speed instruments on pilot's and navigator's panel) which result from simulated changes in air density (pressure altitude-temperature error) and simulated change of load conditions.

(*d*) AIR-SPEED INDICATOR.—The air-speed indicator consists of a receiver telegon which operates the pointer of the instrument. The outward appearance of the dial is identical to that of air-speed indicators used in modern aircraft.

(*e*) THE AIR-SPEED TELETORQUE SYSTEM.—The air-speed teletorque system consists of two teletorques in parallel. As in the case of all teletorques in the Trainer, field terminal (1) is common with (G) of the armature. The 32-volt armature supply transformer is located in the tower junction box. The air-speed transmitter teletorque is driven by the air-speed sylphon bellows in the fuselage, and the case of this teletorque may be rotated by the use of the true air-speed control knob. The connections to the teletorque case are therefore necessarily flexible. Upon failure of this teletorque system, the connection should be checked. The receiver teletorque is located in the wind drift assembly and drives the air-speed follow-up switch.

(*f*) PITCH ACTION AND POWER EFFECT ON AIR SPEED. (*See figures* 35 *and* 48.)—As the Trainer is nosed down the pitch action shaft assembly is moved away from lever (X), which is bolted to the universal pedestal, and the tension of spring (Y) holds coupling lever (U) against lever (X), thus imparting a relative motion to pitch action shaft (PAS) and bell crank (Q). Walking beam (V) pivoted at (O′), assuming throttle linkage to be stationary, causes link rod (R) attached to walking beam at point (R′) to move toward the rear. The reversing lever (S) transmits this motion to the air-speed regulator bellows through spring (T). The air-speed regulator bellows expands and opens the air-speed needle valve admitting more vacuum to the air-speed transmitter bellows, and thus indicates an increased air speed. Advancing the throttle (pushing it forward) actuates link rod (A, figure 48) causing it to move toward the rear. This action is transmitted by bell crank (B) to link rod (D) which moves down, and rotates shaft (M) by means of lever arm (N). The lever arm (N) attached to shaft (M) moves with it, and imparts a rearward motion to link rod (O) which is connected to walking beam at point (O′). In this particular case, the walking beam pivots about point (V′) and moves link rod (R) toward the rear. Reversing arm (S) through spring (T), expands the air-speed regulator bellows and opens the air-speed needle valve. This action allows more vacuum to act on the air-speed transmitter and an increase in air-speed is indicated on the instruments.

(3) THE OUTSIDE AIR TEMPERATURE INDICATOR. (*See figure* 23.)—In order to simulate an air temperature that will be compatible with conditions of true air speed vs. indicated air speed,

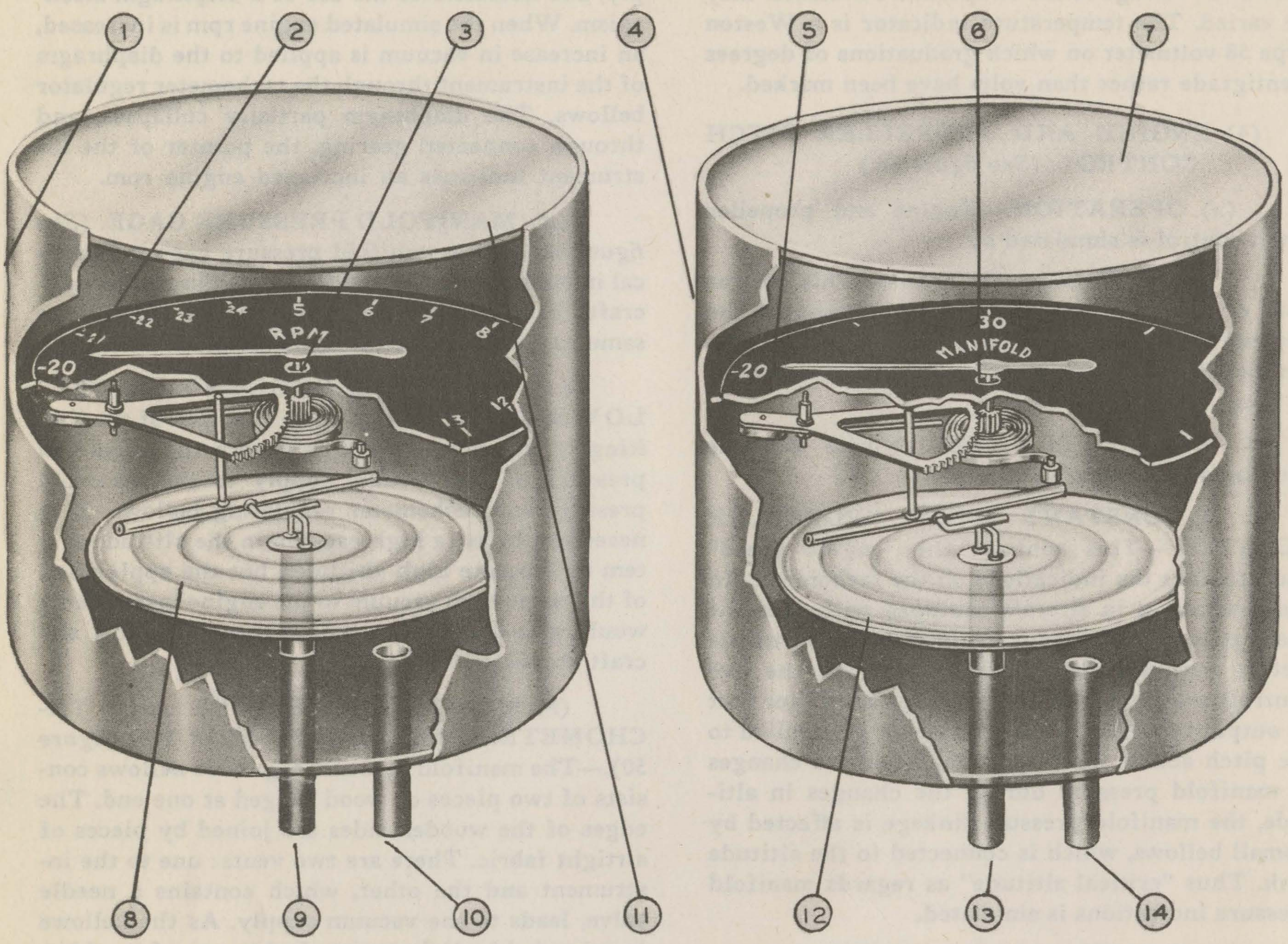

Figure 49—Tachometer and Manifold Pressure Instruments

1. *Case*
2. *Hand*
3. *Hand Staff*
4. *Case*
5. *Hand*
6. *Hand Staff*
7. *Cover Glass*
8. *Diaphragm*
9. *Atmosphere*
10. *To Tachometer Regulator Bellows*
11. *Cover Glass*
12. *Diaphragm*
13. *Atmosphere*
14. *To Manifold Pressure Regulator Bellows*

vacuum to enter the diaphragm of the manifold pressure gage, and a greater manifold pressure will be indicated. The engine rpm will not be affected by throttle action within the limits of the propeller control. When the propeller control is moved forward (toward "increase rpm") link rod (K) moves toward the rear, bell crank (J) pushes link rod (I) downward, and link rod (L) opens the needle valve in the tachometer regulator bellows, admitting more vacuum to the tachometer and indicating an increase in simulated engine rpm.

(5) GYRO-OPERATED INSTRUMENTS.

(*a*) VACUUM SUPPLY.—The gyro-operated instruments, turn and bank indicator and directional gyro, are operated on the turbine vacuum

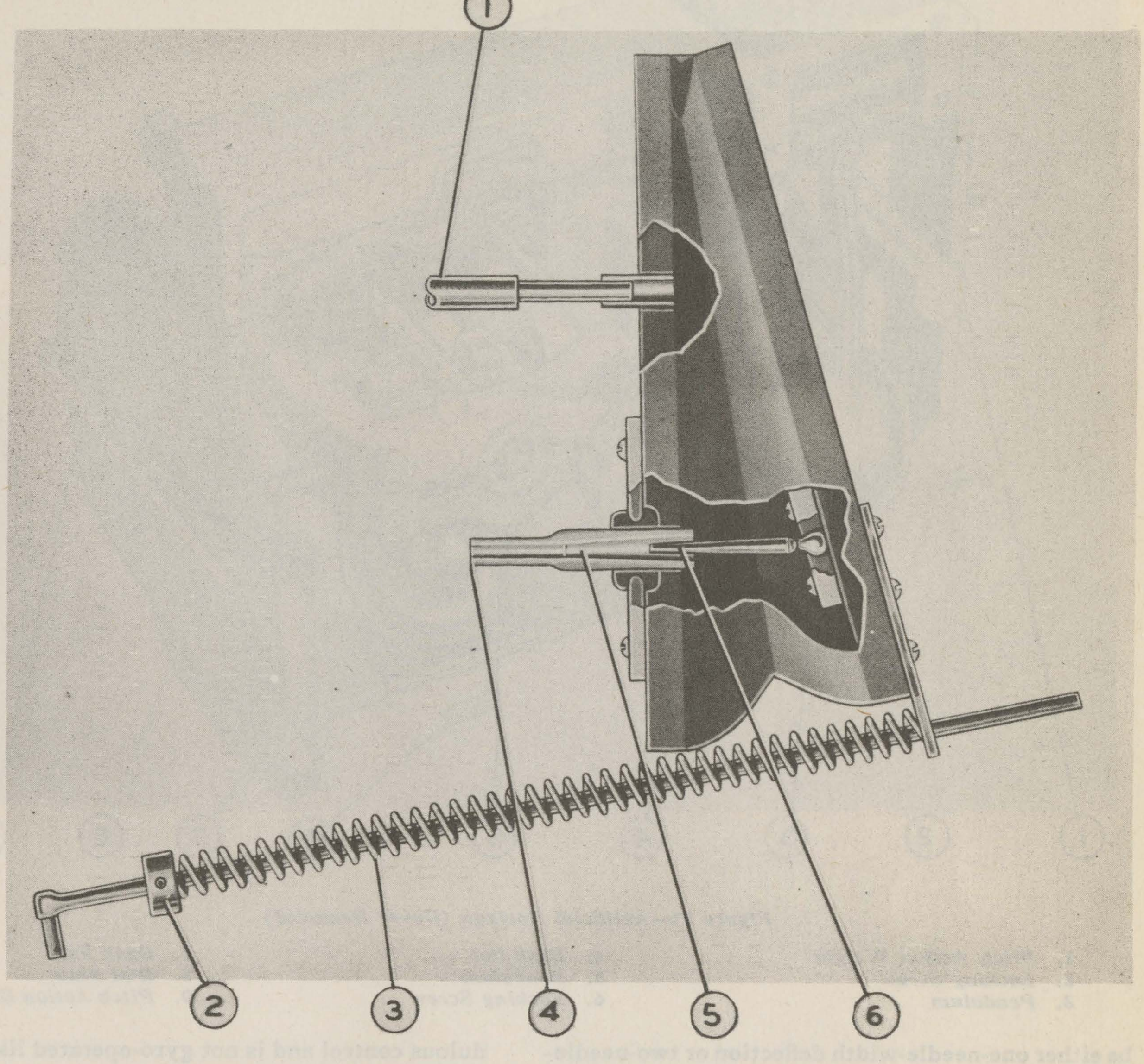

Figure 50—Tachometer and Manifold Pressure Regulating Bellows

1. *Connection to Manifold Pressure Indicator or Tachometer*
2. *Adjustable Stop*
3. *Spring*
4. *Connection to Limiting Bellows*
5. *Needle Valve*
6. *Needle*

supply. A 3/8-inch tube from the main valve manifold is connected through a connector tee to the two regulating bellows on the rear of the pilot's instrument panel. The regulating bellows with the heavy spring controls the vacuum for the directional gyro.

(*b*) TURN AND BANK INDICATOR.—This unit is a standard aircraft instrument except that the inclinometer (bank indicator) is linked to the gimbal ring of the gyro element. This modification is necessary because of the absence of centrifugal force in Trainer turns. The calibration can-

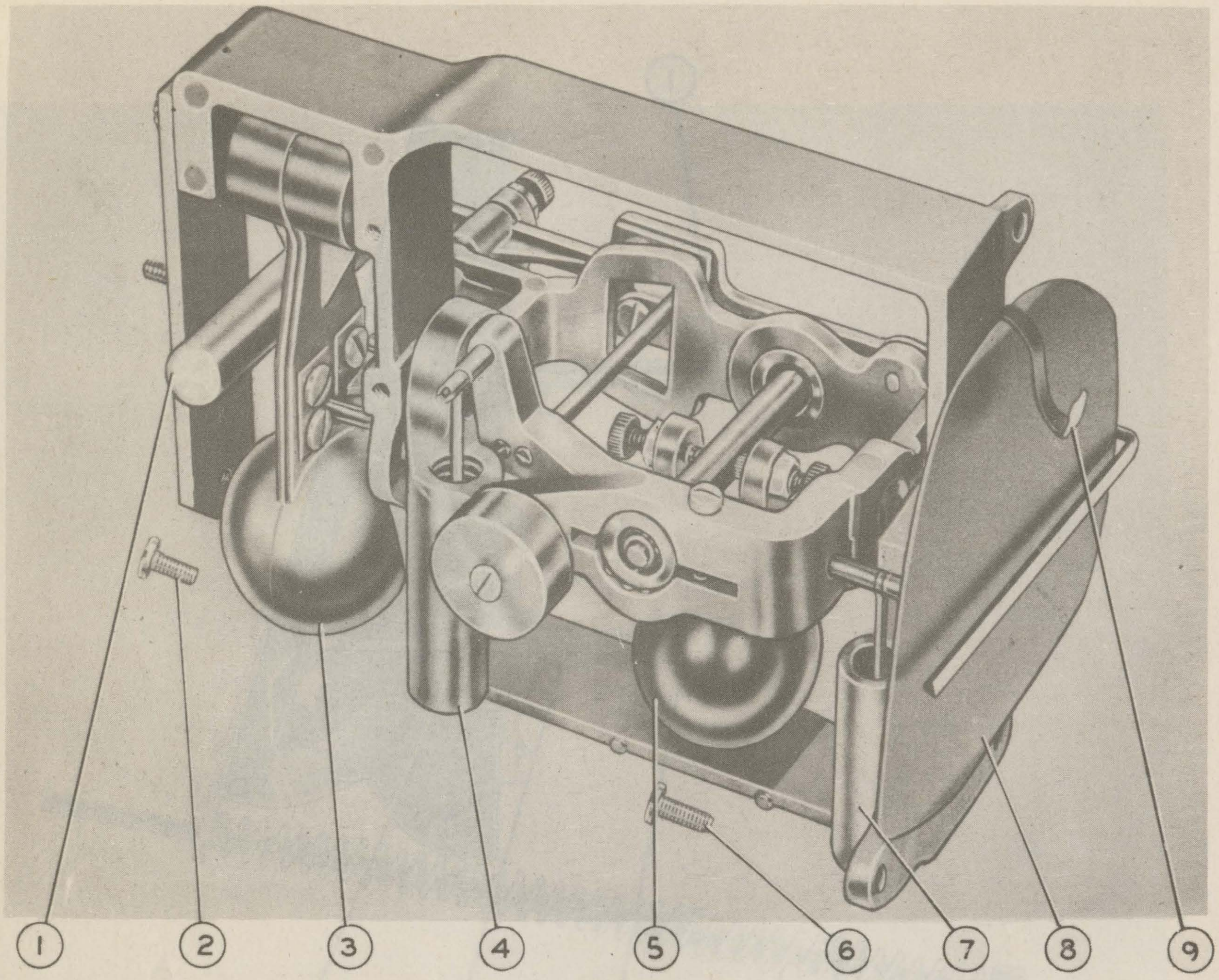

Figure 51—Artificial Horizon (Cover Removed)

1. *Pitch Action Weight*
2. *Locking Screw*
3. *Pendulum*
4. *Dash Pot*
5. *Pendulum*
6. *Locking Screw*
7. *Dash Pot*
8. *Dial Face*
9. *Pitch Action Bar*

be either one-needle-width deflection or two-needle-width deflection for a standard rate turn (180 degrees per minute). If a change is desired from one calibration to the other, it is necessary to change the centering spring.

WARNING

Do not attempt to obtain two-needle-width indications on a one-needle-width instrument by increasing the vacuum. This will ruin the instrument.

(*c*) ARTIFICIAL HORIZON (*figure* 51).—This instrument is a special instrument of pendulous control and is not gyro-operated like the instrument used in an airplane.

(*d*) DIRECTIONAL GYRO.—This unit is a standard aircraft instrument manufactured by Sperry.

(6) REMOTE-INDICATING COMPASS.—The repeater compass transmitter is mounted in the second section of the tower, and by use of a magnesyn (similar to the telegon except that 26-volts at 400 cycles is used) the compass indication is transmitted to the two repeaters in the fuselage. The pilot's compass and navigator's compass are magnesyn units controlling the pointer of a flush-mounted compass.

(7) PILOTS AND NAVIGATOR'S CLOCKS.—The clocks are teletorque-driven and controlled by the time drive motor [section III, par. 1*d*(2)].

i. INDICATOR SYSTEMS.

(1) LANDING SAFETY SIGNALS. (*See figures* 23 *and* 27.)—On the pilot's engine control column are located four indicator lamps and a buzzer. These lamps are all 6-volt lamps with a bayonet-type socket. The 6-volt power supply transformer is located in the fuselage power supply. Two of the indicator lamps are flap-position indicators and the green light shows when the flap switch is up, while the red light shows when the flap switch is down. The other two indicator lamps are for landing gear up or down indications. If the landing gear switch is in the up position and the throttle control is pulled all the way back, a micro-switch is operated, and the buzzer and red indicator lamp both function. If the landing gear switch is in the down position, the circuit to the green landing gear indicator is closed and the lamp lights, the buzzer remaining silent.

(2) BOMB SELECTOR SWITCHES AND BOMB RELEASE SWITCHES.—These switches are of the standard aircraft pattern. With the Trainer master switch "on," a bomb rack must be selected before the bomb release mechanism will operate. The jettison light will go on when the bomb selector switch is depressed, and will go off when the bomb release switch is pressed, if the bomb has left its rack. If there is a hangup, or for some other reason the bomb does not come off the rack, the light will remain on.

(3) INTERPHONE SIGNAL LIGHT. (*See figure* 25.)—There are two fuselage interphone signal lamps, one each located on both the pilot's instrument panel and the radio operator's instrument panel. The circuit to these lamps is closed when any of the interphone signal buttons at the fuselage stations are pressed. The desk interphone signal light is located on the desk instrument panel and the circuit to this lamp is completed only when the instructor's switch is placed on "operator."

j. ELECTRICAL SYSTEM. (*See wiring diagrams, figures* 162 *to* 210 *inclusive.*)

(1) JUNCTION BOXES.

(*a*) All electrical apparatus in the fuselage is connected to three junction boxes. Junction box No. 1 is located on the right-hand side of the fuselage floor under the instructor's seat. Junction box No. 2 is located on the fuselage floor between the pilot's control column and the rear of the Trainer. Junction box No. 3 is located on the side of the fuselage behind the pilot's seat. The SCR-269-A relay box is located under the fuselage floor between the two longitudinal central frame members toward the pilot's control column from the bomb sight mounting bracket.

(*b*) All 12-wire and 33-wire cables are fitted with Jones plug connectors, where necessary, and they can be easily removed. Wires to vibrator motors and lights are connected to binding posts in the junction boxes.

(*c*) Two transformers are mounted in fuselage junction box No. 1 to supply the fluorescent lights on the pilot's and navigator's panels. Instruments are connected with A-N type connectors.

(2) FLUORESCENT LAMPS (*figure* 52).

(*a*) There are two units which supply fluorescent lighting to the navigator's and pilot's instrument panels. Each unit supplies fluorescent and ultra-violet light, according to the type of light desired. If the whole panel is to be lighted, fluorescent light is supplied through slot (I) in case (D) which is rotatable. For instrument indications only, the case is rotated, and ultra-violet light is supplied through screen (H) to activate the luminous dials of the instruments. The intensity of either type of light is controlled by rotation of the shutter (J) inside the case by means of knurled knob (G) on the end of each lamp.

(*b*) These lamps are supplied by a high reactance transformer by means of which it is possible to obtain a high voltage starting kick and a low normal operating voltage. An automatic starter is a part of each unit. This starter operates the filaments of the tube for a few seconds, heating the mercury vapor in the tube and aiding ionization. The contacts of the starter then open and turn off the filaments at the same time placing a relatively high voltage across the tube. This kick across the tube should cause it to "fire." If not, the whole process is repeated. When the tube fires, the mercury vapor is ionized and the resistance of the tube drops considerably. However, as the tube draws more current, the voltage across the tube drops because of the high reactance supply transformer. In this manner a balance is reached.

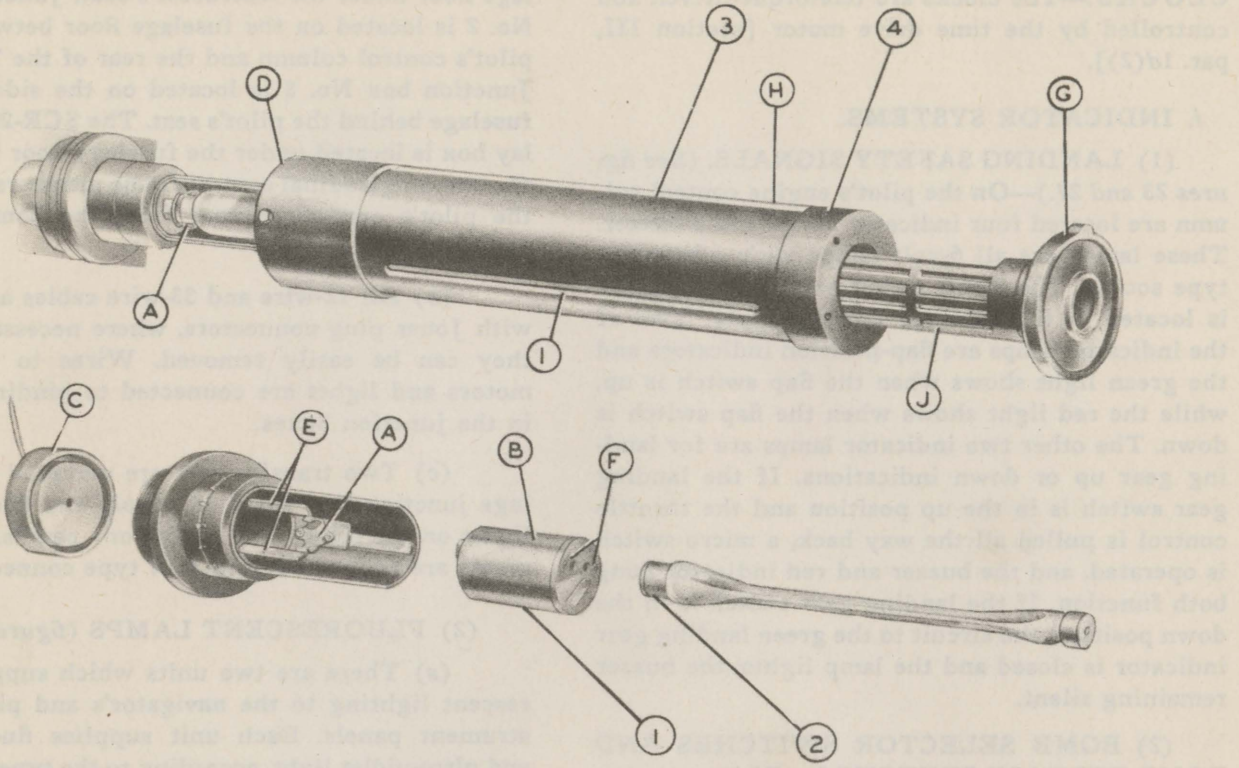

Figure 52—Fluorescent Lamp

1. *Fluorescent Lamp Starter Switch*
2. *Fluorescent Bulb*
3. *Ultra-Violet Screen*
4. *Lamp Case*

(*c*) Failure of either the bulb or starter unit will cause failure of the lamp. To replace the starter, dismantle the lamp from the base and disconnect the wiring by removing plug (C). The starter may be removed by pushing it out of the base with a blunt instrument. To install the new unit, lift up slightly on prongs (E) to engage slots (F) and make contact. Reconnect and test for proper actuation of the lamp.

(*d*) The bulbs are of the 4-watt size. To dismantle the lamp and replace the bulb, pull the bakelite case from the base as illustrated. To remove the bulb, pull it out of clip fasteners (A) on each end, after first unsnapping the bottom clip. Insert the new bulb with its flat surface flush with the metal receptacle. In reassembling the lamp, be careful not to damage the shutters or the case, as bakelite moldings break easily.

(3) THE INSTRUMENT PANEL VIBRATOR MOTORS (*figure* 53).—On the pilot's instrument panel, navigator's instrument panel, differential pressure regulator and altitude transmitter are mounted 6-watt, 115-volt, synchronous motors. Eccentric weights are mounted on the shaft so that the instrument panels will vibrate as the motors run. The weights may be adjusted on the shaft to compliment or neutralize their unbalance, thus the amplitude of vibration may be increased or decreased. The proper amount of vibration will prevent the instruments from sticking, but not cause erratic indications due to excess vibration. Switches are provided in series with each motor so that the vibrators may be turned on or off as desired.

(4) MISCELLANEOUS LIGHTING.—Incandescent lighting is supplied by a 6-volt dome light for exit and entry illumination, a 6-volt spot light to illuminate the radio operator's desk, and a 110-volt table lamp for the navigator. The spot light is controlled by a rheostat and switch on the base of the spot itself, and the navigator's desk

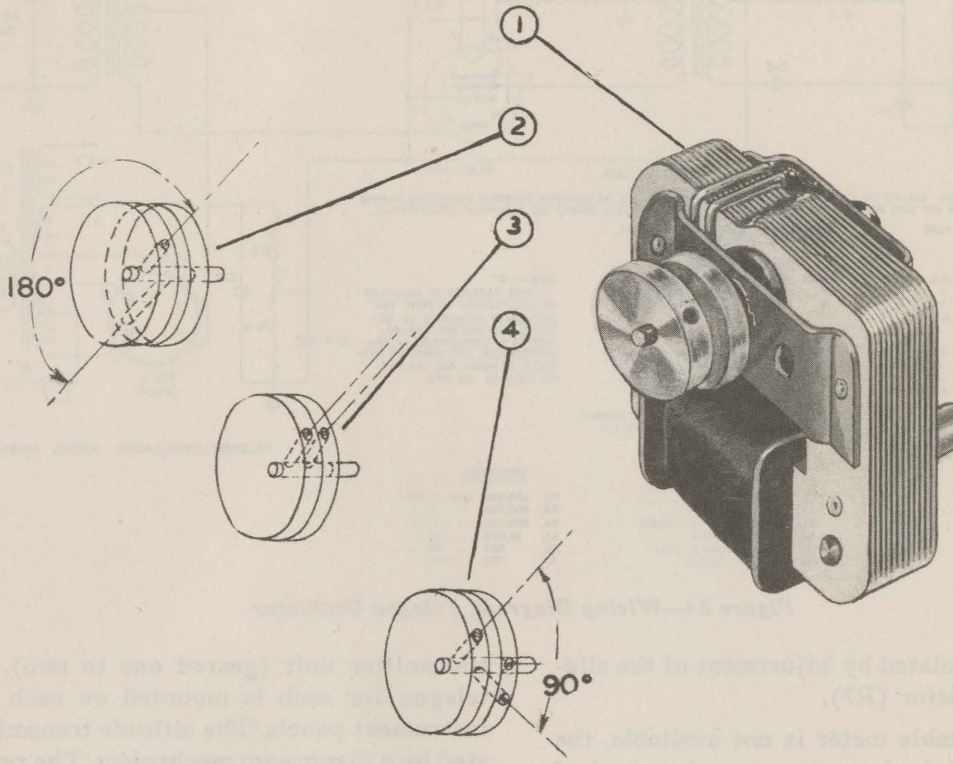

Figure 53—Vibrator Motor

1. *Motor*
2. *Minimum Vibration Position*
3. *Maximum Vibration Position*
4. *Normal Vibration Position*

lamp is controlled by a rheostat in the 110-volt line to the lamp. The 6-volt supply transformer for the dome and spot lights is located in the fuselage power supply.

(5) TELEGON OSCILLATOR (*figure* 54).

(*a*) The function of this unit is to supply 700-cycle to 800-cycle current for the remote-indicating instruments. It utilizes a type 83 v rectifier tube; and three 6L6 (G) tubes; one as an oscillator and the other two as amplifiers to increase the power to the necessary level for proper operation of the instruments.

(*b*) Power supply to the telegon oscillator should be 110 volts to 115 volts at 50-cycle to 60-cycle frequency. The output of the unit should be 80 volts to 90 volts, 700 to 800 cycles per second. The voltage must be measured under full load condition (all remote instruments properly connected).

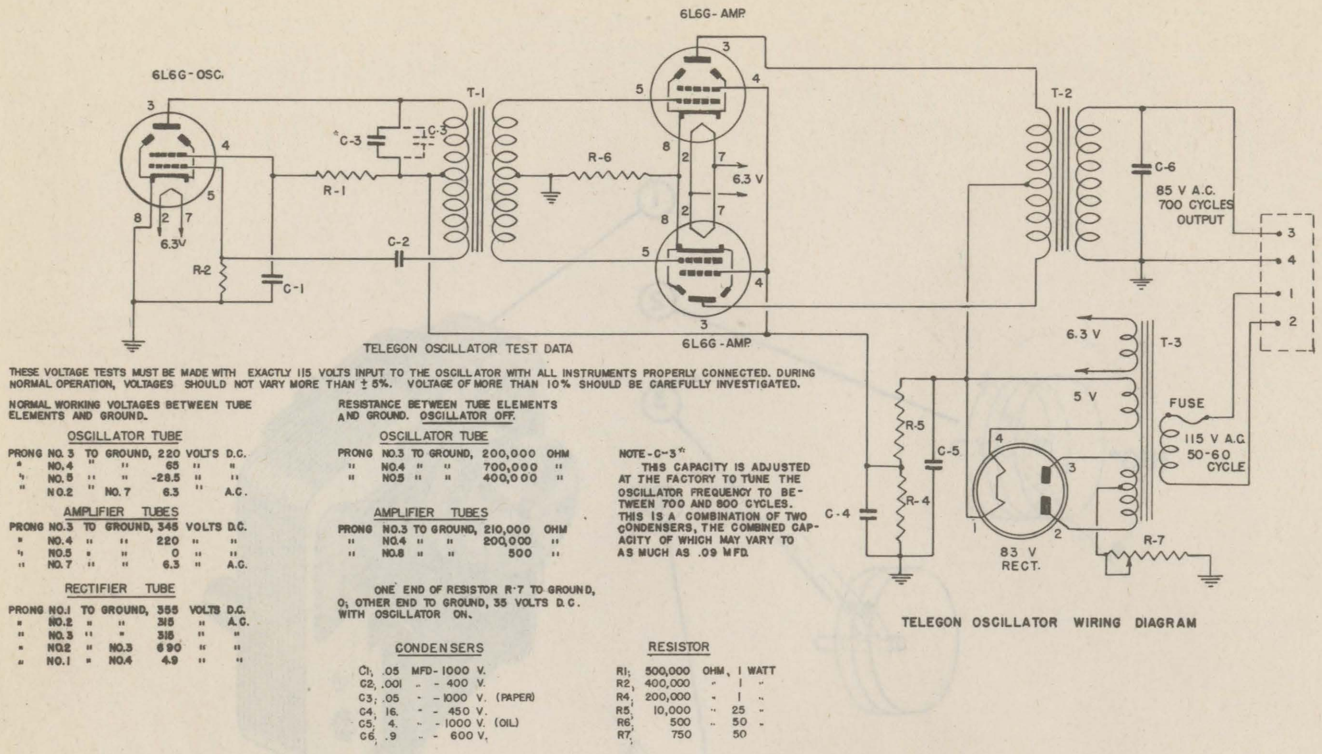

Figure 54—Wiring Diagram, Telegon Oscillator

Voltage can be regulated by adjustment of the sliding contact on resistor (R7).

(*c*) If a suitable meter is not available, the 700-cycle to 800-cycle frequency may be checked by touching one tip of a pair of headphones to one side of the output and comparing the tone with any source of a 700 cycle to 800 cycle note such as produced by a tuning fork or other musical instrument. The frequency may be adjusted by slight changes in the capacity of condenser (C3).

(*d*) On rare occasions it has been necessary to vary the value of condenser (C6) from as little as .5 mfd to as much as 1.5 mfd to obtain the correct output. This change should not be made, however, until everything else has been proven perfect.

(6) THE TELEGON SYSTEM OF REMOTE INDICATION (*figure* 55).

(*a*) The Kollsman telegon system of remote indication is used on the Trainer in order to have identical instrument readings on duplicate sets of instruments, one set located on the pilot's instrument panel and the other on the navigator's instrument panel.

(*b*) The system consists of a special airspeed transmitter unit and a Kollsman altitude transmitter unit (geared one to two). A receiver telegon for each is mounted on each of the two instrument panels. The altitude transmitter is actuated by a diaphragm mechanism. The receiver units consist of a telegon unit which is structurally identical with the transmitter telegon unit and which carries the instrument dial and hand.

(*c*) The top view of a telegon unit with the end bells and case removed shows the arrangement of terminals. This unit is enclosed in an iron shell and aluminum end bells, which complete the case, are held by four brass clamp screws (*figure* 56).

(*d*) The unit consists of a spool assembly, four terminals, two terminal insulators, the shell and two end bells. The spool assembly contains the shaft assembly (K), the primary coil (M) and the phase windings (F-F'). The four terminals are connected to the primary coil and the two-phase windings.

(*e*) The system functions as follows: The primary coil (M) is energized with 85 volts, 700 cycles to 800 cycles per second from an external source and the alternating magnetic flux produced by this coil follows the path of least resistance which is the iron shaft assembly (K) and the vanes.

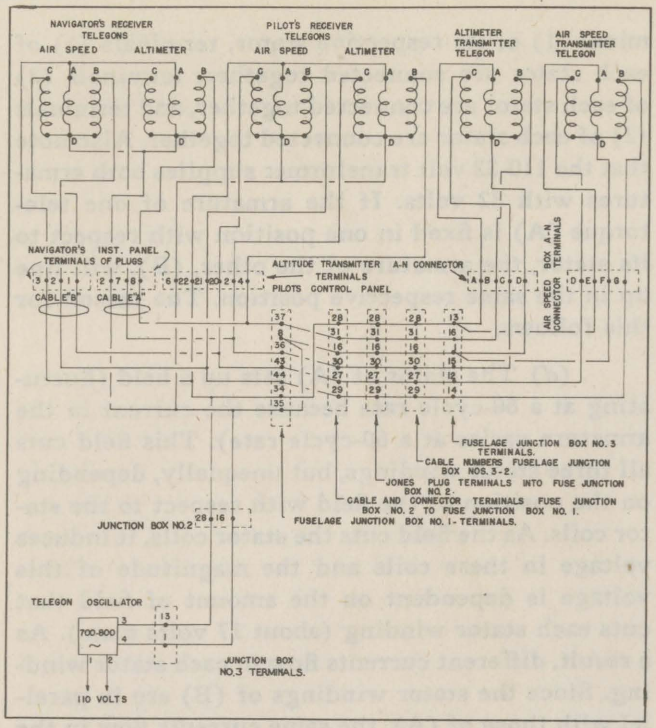

Figure 55—Wiring Diagram, Air Speed and Altitude Telegon System

The magnetic circuit is completed through the outer iron case (S). When the shaft assembly of the transmitter unit is rotated, the magnetic field around the vanes is also rotated. This field pattern induces a voltage in the phase windings (F-F′) whose magnitude is proportional to the flux cutting the phase winding.

(*f*) The voltages thus induced cause proportional currents to flow in the phase windings (F-F′) and in the phase windings of the receiver unit since the two units are connected in parallel. Therefore, a flux pattern is set up in the receiver unit identical to that in the transmitter unit. This field and the field on the vanes of the receiver unit line up north to south and south to north and thus the armature of the receiver unit assumes the same position with respect to the transmitter phase windings.

(*g*) The telegon system will function indefinitely with proper usage. Under no circumstances should the actual telegon unit be removed from its case or disassembled unless there is a definite indication that trouble is located in the unit. It will usually be found that the trouble lies with faulty connections to the unit. The resistance of the primary should be 225 ohms to 300 ohms and that of the phase windings 900 ohms to 1100 ohms.

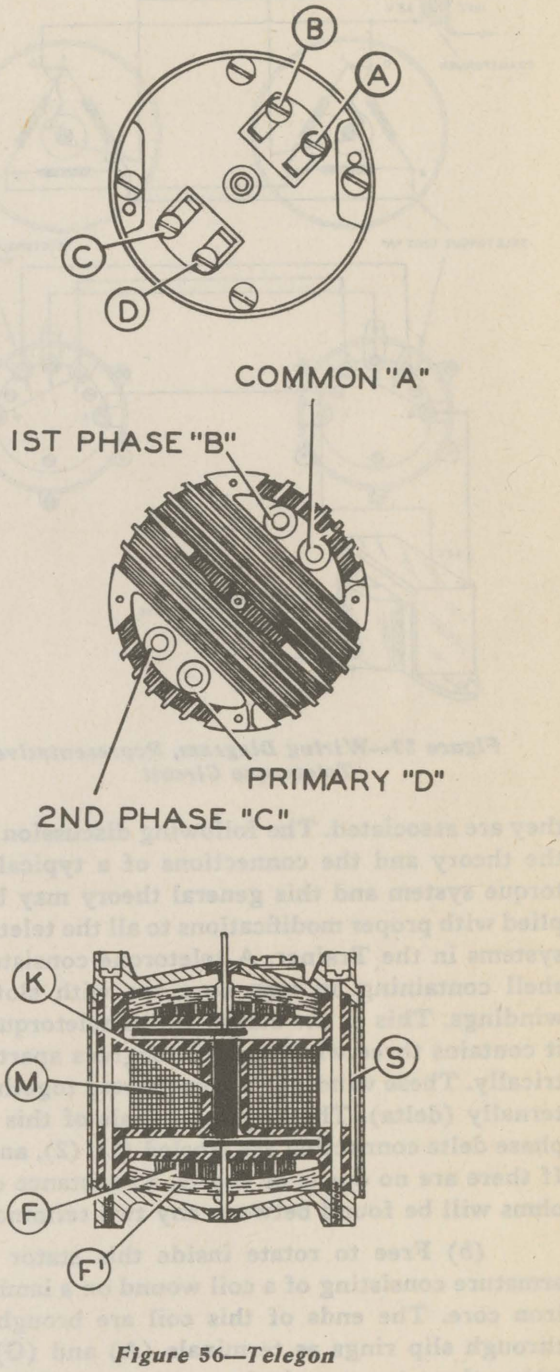

Figure 56—Telegon

(7) THE TELETORQUE SYSTEM OF REMOTE CONTROL. (*See figure* 57.)

(*a*) Electrical linkage in the form of a teletorque system has been used in the Trainer wherever distance makes mechanical linkage impractical. The various systems, their purposes, and their circuits are discussed under the units with which

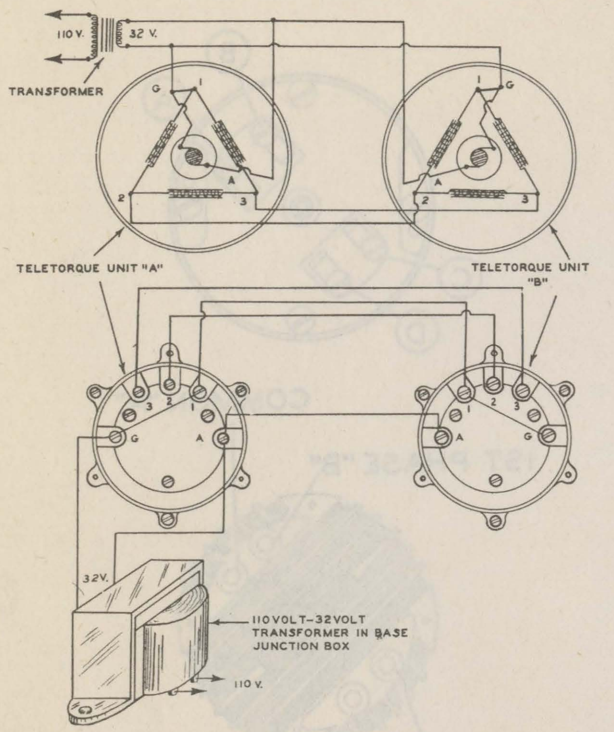

Figure 57—Wiring Diagram, Representative Teletorque Circuit

they are associated. The following discussion gives the theory and the connections of a typical teletorque system and this general theory may be applied with proper modifications to all the teletorque systems in the Trainer. A teletorque consists of a shell containing an iron core cut with slots for windings. This is the stator of the teletorque and it contains three windings, 120 degrees apart electrically. These windings are connected together internally (delta). The three terminals of this three phase delta connection are labeled (1), (2), and (3). If there are no opens or shorts, a resistance of 700 ohms will be found between any two terminals.

(*b*) Free to rotate inside this stator is an armature consisting of a coil wound on a laminated iron core. The ends of this coil are brought out through slip rings as terminals (A) and (G). Between these two terminals a resistance of 70 ohms may be measured if there are no opens or shorts in the coil. This winding is supplied with 32 volts at 60 cycles.

(*c*) When two teletorques are used in the Trainer as a motion transfer mechanism, they are connected as illustrated (figure 57). Note that terminal (G) of each armature is connected to terminal (1) of its respective stator, terminals (1) of each stator are connected together, terminals (2) of each stator are connected together, and terminals (3) of each stator are connected together. Also note that the 110-32 volt transformer supplies both armatures with 32 volts. If the armature of one teletorque (A) is fixed in one position with respect to its stator, the armature of the other, (B), will line up in the same respective position. The reason for this follows.

(*d*) The stator of (A) sets up a field (fluctuating at a 60-cycle rate because the current in the armature varies at a 60-cycle rate). This field cuts all three stator windings, but unequally, depending on the position of the field with respect to the stator coils. As the field cuts the stator coils, it induces voltage in these coils and the magnitude of this voltage is dependent on the amount of field that cuts each stator winding (about 17 volts max.). As a result, different currents flow in each stator winding. Since the stator windings of (B) are in parallel with those of (A), the same currents flow in the stator coils of (B) as in (A). Therefore, the stator of (B) sets up a field in (B) exactly similar to the field of (A). Since the armature of (B) is connected to a 32-volt 60-cycle source as in the armature of (A), there is also a field in the armature of (B) similar to that in the armature of (A). Since two magnetic fields always tend to line up north to south and south to north, these two fields in (B) lock together. This, of course, brings the armature of (B) into the same position with respect to the stator of (B), that the armature of (A) occupies with respect to the stator of (A).

(*e*) If the position of the armature of (A) is now changed, the armature of (B) changes a like amount. Since the two units are identical, the whole system may work from (B) to (A) as well as from (A) to (B) as described. The determining factor as to whether one unit shall transmit or receive is whether the unit is being driven mechanically or not. For example, the track transmitter teletorques on the wind drift mechanism are transmitters because they are driven by the wind drift unit. The track receiver teletorques in the terrain plate drive determine the direction of drive of the plate; but they are not mechanically driven by any unit. If the latter should be held in one position while the former was moved, the receivers would then be transmitters, and the result would be electrical slippage somewhere in the system. Thus it may be seen that **any** teletorque system will fail if an ab-

normal amount of torque is applied to the armature of the receiver.

(*f*) It is well to note also that if there are any opens or shorts in the circuit between the teletorques or inside the teletorques, the system will fail. The result in the case of an open circuit is generally oscillation back and forth rather than complete revolution at the receiver. An intermittent open circuit may cause the teletorque to rotate continuously or it may cause erratic action.

(*g*) The direction of rotation of any receiver teletorque may be reversed by reversing terminals (2) and (3) of the stator.

k. THE INTERPHONE SYSTEM.

(1) GENERAL DESCRIPTION.

(*a*) The Trainer interphone system consists of five stations complete with earphones, microphones, signal buttons, and signal lamps. Controls are provided where necessary for operation of the system. The system involves the use of two amplifiers (and their respective power supplies), the radio-control-chassis interphone amplifier, and the fuselage amplifier. The radio operator and pilot are supplied with switches which on the "radio" position puts them on the fuselage radio output with input into the radio system, and on the "interphone" position ties their earphones and microphones into the fuselage interphone system. The navigator's headset and microphone is always tied to the fuselage interphone system. The instructor's station is equipped with a three-position switch for selecting either "off," "crew," or "operator." In the "crew" position his set is tied to the fuselage interphone system and when on "operator" position his set is tied to the desk interphone system. The following is an outline of station location and controls:

Station	*Location*	*Controls*
Navigator's	Left of the bombardier's control panel.	Signal button.
Pilot's	Above and to the left of the pilot's seat.	"Radio-Interphone" toggle switch. "Range-Simultaneous-Voice" selector switch. Signal button.
Radio Operator's	Above and to the rear of the radio operator's desk.	"Radio-Interphone" toggle switch and signal button.
	On the fuselage amplifier.	Volume control.
Instructor's	To the right of and above the instructor's seat.	Signal button. Three-position "Off-Crew-Operator" selector switch.

(*b*) The amplifier in the radio control chassis is the desk interphone system amplifier, and the fuselage unit is the fuselage interphone system amplifier.

(2) THE FUSELAGE AMPLIFIER. (*See wiring diagram, figure* 205.)—The fuselage interphone amplifier consists of a self-biased (6V6) tube with input and output transformers, and a 250,000 ohm potentiometer on the output to the control grid as a volume control. Self-biasing is accomplished with a 250-ohm resistor and a 40-mfd bypass condenser in the cathode lead.

(3) THE FUSELAGE POWER SUPPLY. (*See wiring diagram, figure* 197.)—The fuselage power supply contains two dry rectifiers and one full wave electronic rectifier (5T4). One dry rectifier supplies filtered 6-volt direct current for the mikes and for the temperature indicator system. The other supplies 12-volt direct current for the compass deflector. The B plus output from the (5TR) transformer supplies the fuselage interphone amplifier. On the power supply is a phone jack for a code key, and an "on-off" switch for the power supply.

l. RADIO (*See section* III, *par. 6d.*)

m. MISCELLANEOUS EQUIPMENT.

(1) Mounting brackets are provided for the following items:

(*a*) Drift Indicator
(*b*) Astro Compass
(*c*) Astrograph
(*d*) Bomb Sight

(2) There is space provided on the pilot's panel for an instrument landing system and a pilot direction indicator.

3. TOWER AND COUNTERBALANCE FRAME.

(*See figures* 58 *and* 59.)

a. INTRODUCTION.

(1) The tower is a welded steel tube structure which is mounted on the counterbalance frame and supports the fuselage. Mounted on the tower is the universal (at the top), the projection screen, the pitching bellows brackets (near the top), the artificial north magnet, variation control drive, and radio loop drive. At the bottom of the tower is a wooden platform on which is mounted the wind drift mechanism and controls, bomb hit timer, dry rectifier, and inverter.

(2) The counterbalance frame is a welded carriage assembly of channel iron which is fastened to

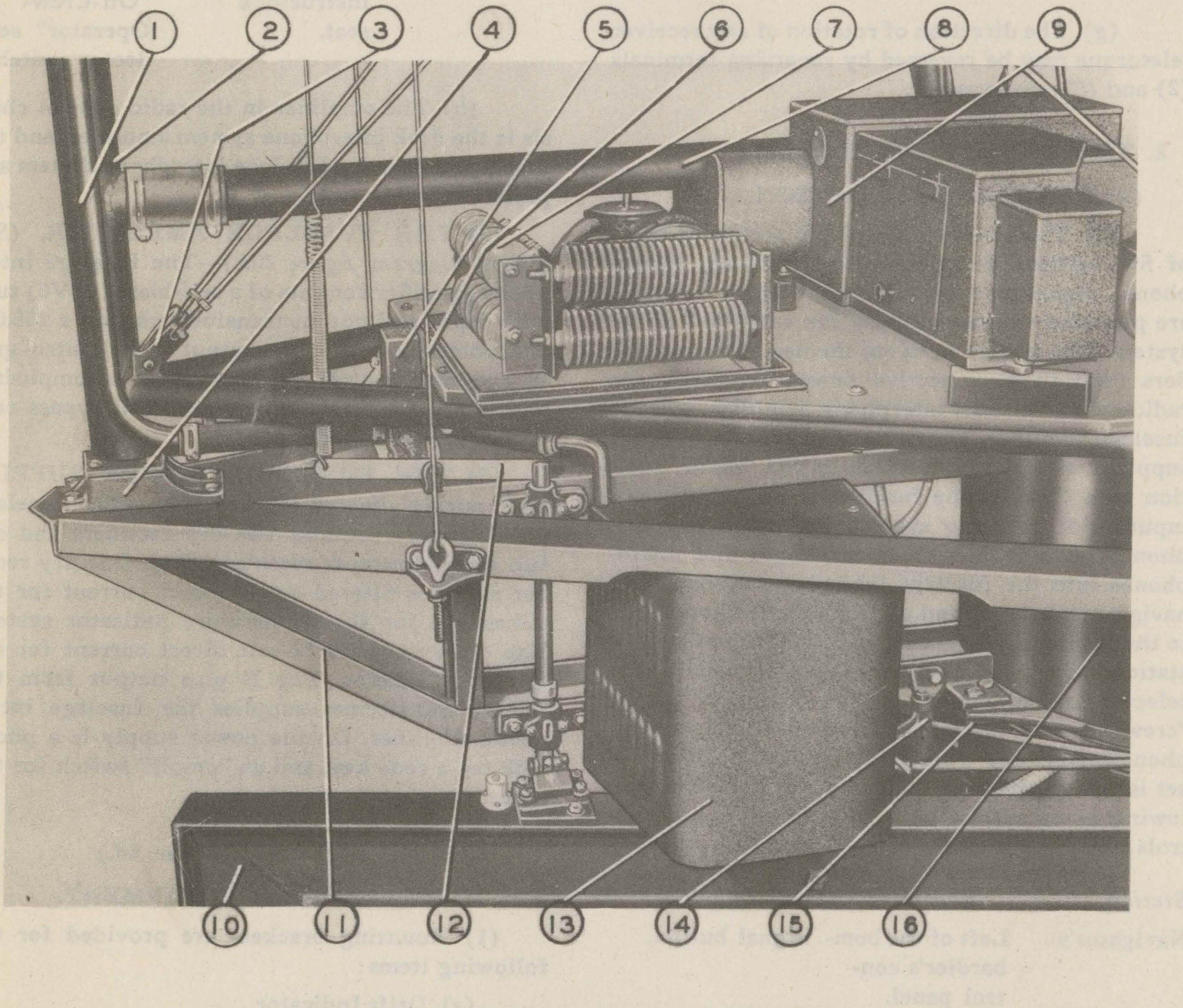

Figure 58—Counterbalance Frame—One Third View

1. ***Turning Motor Vacuum Manifold***
2. ***Rear Tower Leg***
3. ***Tower Tie Rod Clevis***
4. ***Tower Leg Mounting Pad***
5. ***Anti-Turn Solenoid***
6. ***Banking Bellows Cable***
7. ***Rectifier***
8. ***Turbine Vacuum Manifold***
9. ***Wind Drift Assembly***
10. ***Trainer Base Frame***
11. ***Counterbalance Frame***
12. ***Tower Locking Device***
13. ***Turning Motor***
14. ***Turning Motor Belt Tightener***
15. ***Turning Motor Belt***
16. ***Main Bearing Hub***

the main bearing hub and revolves about it. The frame carries the tower, fuselage, and associated electrical and mechanical equipment.

b. TOWER ASSEMBLY. (*See figures 58 and 59.*)

(1) CONSTRUCTION.—The Trainer tower which supports the fuselage is a triangular structure of pyramid appearance, made of welded steel tubing and adjustable cross bracing to give the necessary strength and rigidity. The tower is 16 feet 2 inches high from counterbalance frame to the top of the tower pedestal. The base of the tower is 4 feet 10-1/4 inches between the two front legs, mounted on each side of the main bearing, and 4 feet 9-1/2 inches from the center line of the front

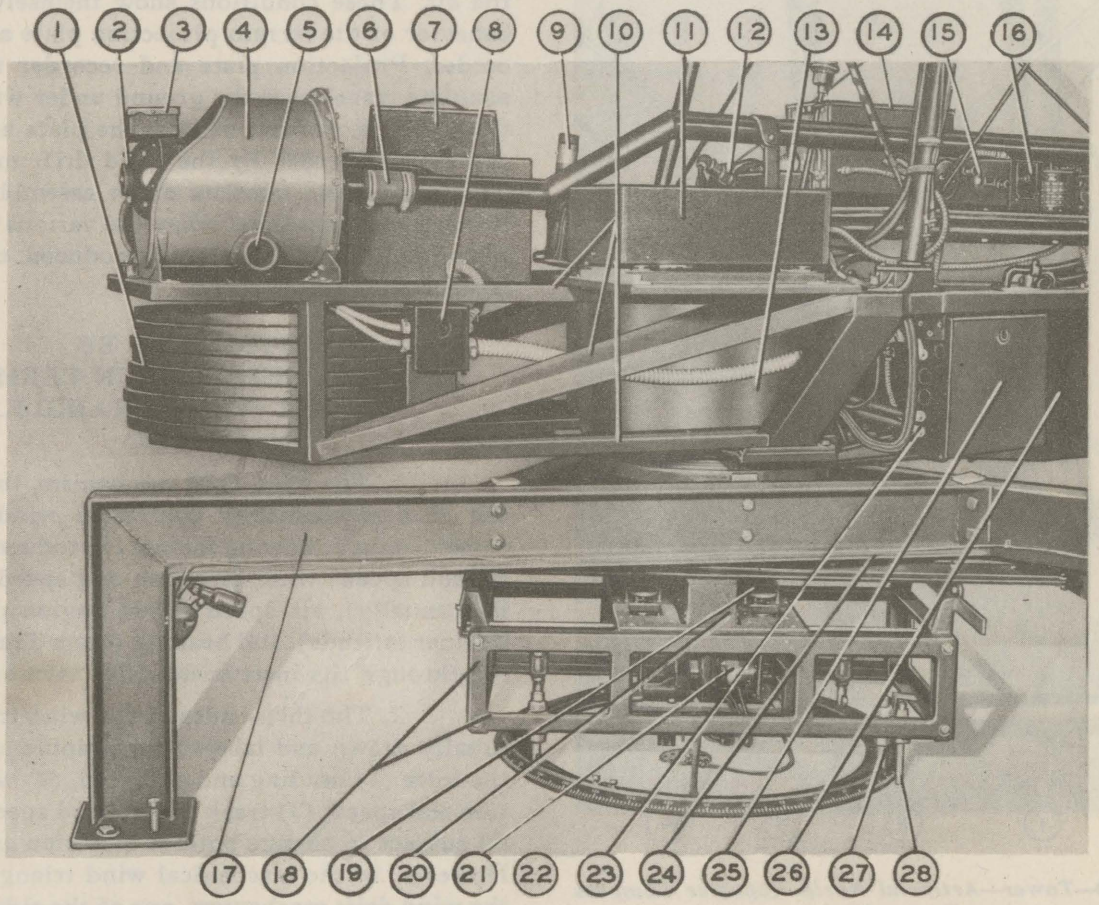

Figure 59—Counterbalance Base and Tower Mechanism—Three Quarters Rear View

1. *Tower Counterbalance Weights*
2. *Turbine Motor*
3. *Turbine Condenser Box*
4. *Turbine*
5. *Turbine Exhaust Port*
6. *Turbine Exhaust Hose Connection*
7. *Cloud Projector Assembly*
8. *Turbine Junction Box*
9. *Bomb Hit Projector*
10. *Counterbalance Frame*
11. *SCR-269-A Receiver*
12. *Inverter*
13. *Main Bearing Hub*
14. *Wind Drift Assembly*
15. *Wind Speed and Direction Control Panel*
16. *Bomb Hit Timer Control*
17. *Trainer Base Frame*
18. *Terrain Base Frame*
19. *Projection Plate Ground Speed Autosyns*
20. *Terrain Projector*
21. *Azimuth Rail*
22. *Projector Fan Motor*
23. *Turning Motor Belt*
24. *Projection Plate Carriage*
25. *Tower Junction Box*
26. *Turning Motor*
27. *Terrain Base Adjustable Stud Rollers*
28. *Stud Frame Stop*

legs to the center line of the rear legs. The tower pedestal is supported by six short lengths of tubing, two at the top of each leg, welded to give proper bracing and position to the pedestal. A plate for mounting the universal pedestal is welded to the top of the tower pedestal tube and four slots are cut near the bottom of the tube. The leveling device pulleys are mounted on welded brackets in these slots. The rear tower leg serves as piping for the

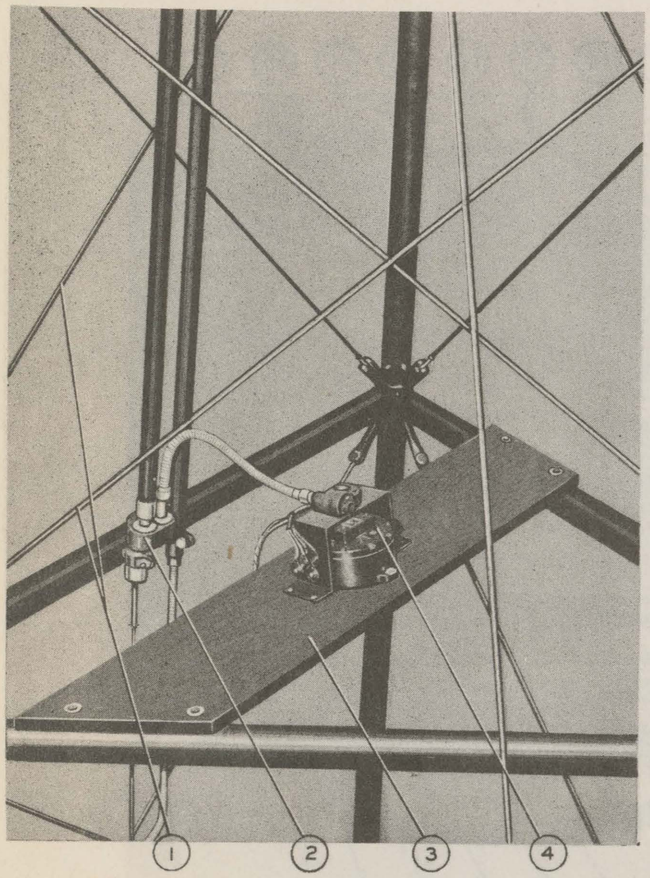

Figure 60—Tower—Artificial North Repeater Compass Transmitter

1. *Tower Tie Rods*
2. *Compass-Variation Drive*
3. *Artificial North Platform*
4. *Artificial Magnetic Compass Transmitter*

vacuum supply lines from the counterbalance frame to the fuselage. The left front tower leg, as viewed from above when the Trainer is on an east heading, encloses the 33-wire cable from the tower junction box to the fuselage.

(2) EQUIPMENT.—A platform of 7/8 inch plywood on the lower section of the tower carries the wind drift mechanism and controls, bomb hit timer, and radio power supply. The artificial magnetic compass transmitter is mounted on a similar wood platform on the second section of the tower.

(3) WIND DRIFT MECHANISM. (*See figure* 62.)

(*a*) GENERAL.—It is necessary to provide simulated wind conditions in order that the navigator and the pilot working in the Trainer may be subject to the same conditions as they would be in the air. These conditions show themselves in the behavior of the terrain projection plate and the recorder. Projection plate and recorder movement simulate travel over the ground under wind conditions. The movement of both the plate and the recorder is governed by the wind drift mechanism. This mechanism consists of an assembly of gear trains so arranged that when the various factors of the wind drift problem are introduced, the output is track and ground speed.

(*b*) CONDITIONS TO BE REPRESENTED IN TERMS OF THE WIND TRIANGLE. (*See figure* 63.)

1. The wind drift mechanism, through the use of a mechanically controlled wind triangle, combines the following factors to produce track and ground speed: wind direction and speed (cranked in manually), air speed (from engine power and Trainer attitude), and heading (from Trainer heading through the instrument drive take-off).

2. The three sides of the wind triangle are usually drawn and labeled for graphic solution in the form (1) heading and air speed, (2) wind direction and speed, (3) track and ground speed, and are all subject to change both in direction and length. However, in the mechanical wind triangle used in the wind drift mechanism, one of the sides (AB) is fixed in direction and for mechanical reasons the wind triangle elements are arranged as follows: air speed (AB), wind speed (BC) and relative wind angle (ABC), the latter being the angle between the heading and the wind direction. From these are produced the ground speed (CA) and the drift angle (CAB).

3. To illustrate how the wind triangle in the wind drift mechanism meets the necessary conditions assume that an aircraft, flying on a north heading at 160 mph air speed, encounters a wind from the east blowing at 60 mph. The relative wind angle is 90° right. The aircraft, under these condi-

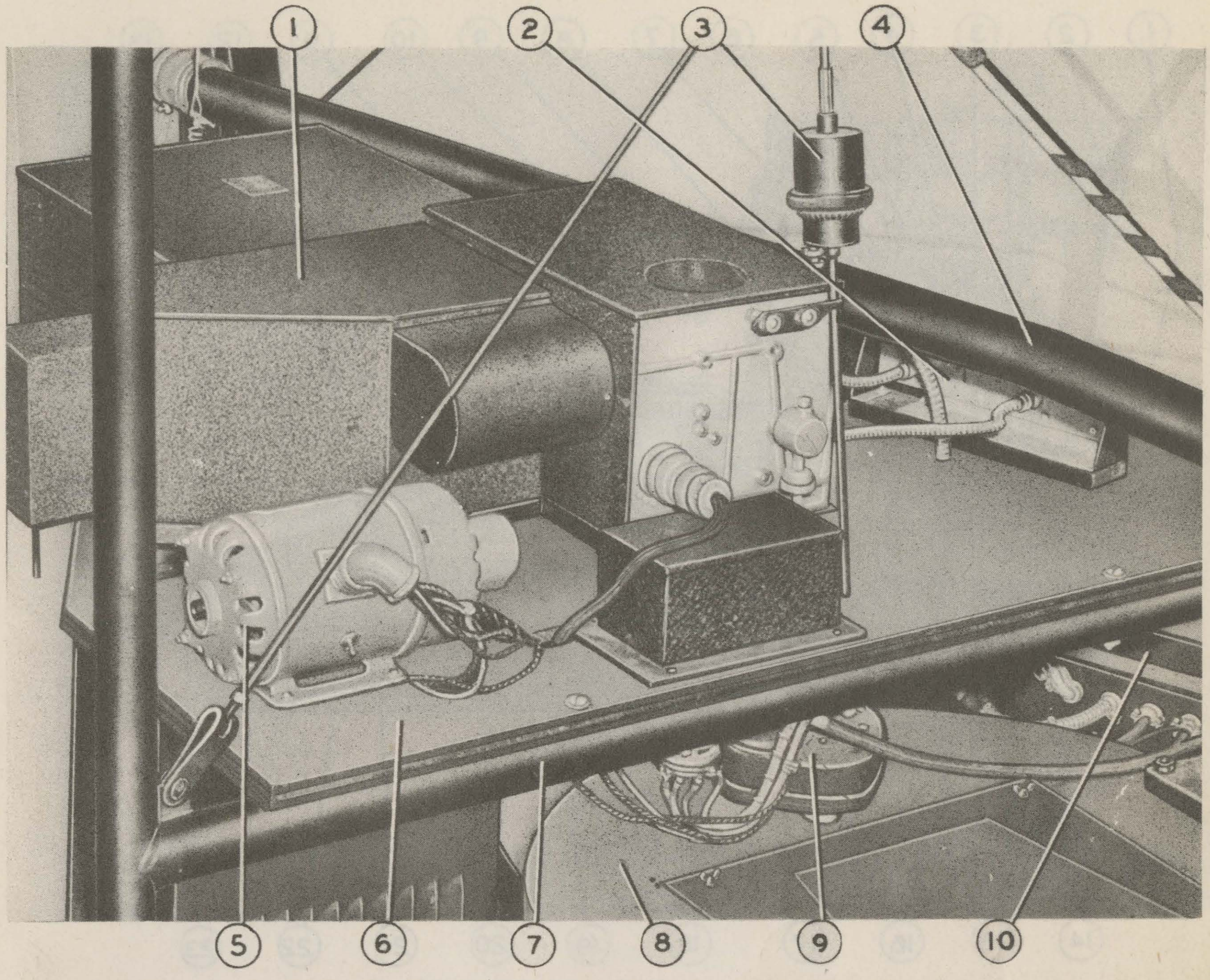

Figure 61—Wind Drift Platform and Tower—General View

1. *Wind Drift Assembly*
2. *Wind Speed and Direction Control Assembly*
3. *Compass Variation Control*
4. *Trainer Vacuum Manifold*
5. *Inverter*
6. *Wind Drift Platform*
7. *Tower Frame*
8. *Main Bearing Hub Cover*
9. *Instrument Drive Take-Off*
10. *Tower Junction Box*

tions, will be blown to the left at an angle of 20° to the heading; that is, the drift angle will be 20° left. Consequently, the track will be 360° minus 20° left drift or 340°. The ground speed will be 171 mph.

(c) THE MECHANICAL WIND TRIANGLE. (*See figure* 64.)

1. The wind may be thought of as always blowing down the side (BC, figure 63). (AB) may be thought of as representing the heading of the aircraft. Angle (ABC) is the angle which the heading of the aircraft makes with the wind, or the relative wind angle. Since the direction of the side (AB) is fixed in the mechanical wind triangle, this relative wind angle is varied by rotating the wind bar (BC, figure 64) in either one or both of two ways. For example, when the Trainer rotates, that is, when the heading is changed, the wind bar (BC) is made to rotate in the **same** direction as the Trainer. When the wind direction is altered the bar is made to rotate in the **opposite** direction to the shifting wind. The two movements are applied simultaneously to the wind bar through the relative wind angle differential (RWAD, figure 64). Head-

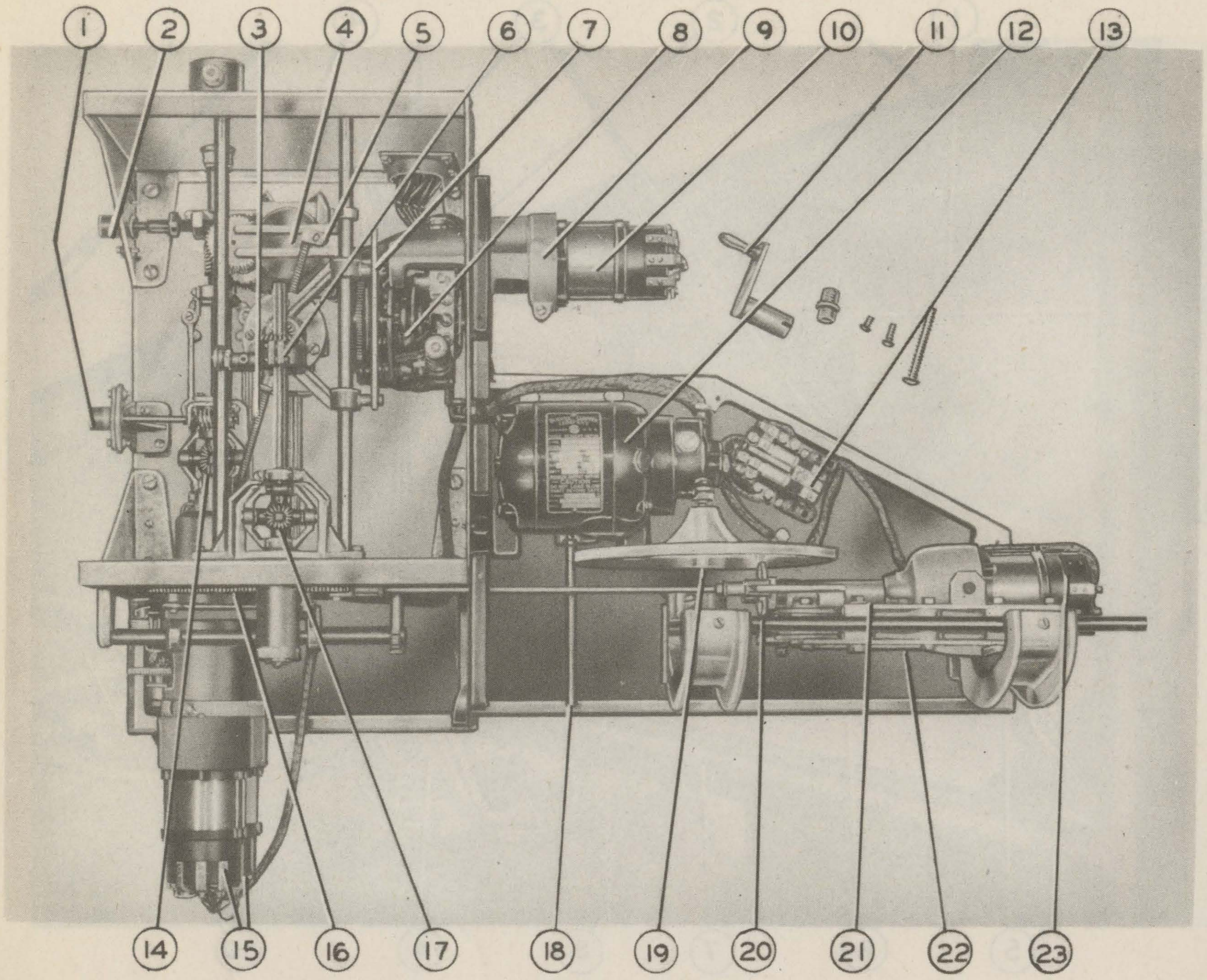

Figure 62—Wind Drift Assembly—Top View

1. *Wind Direction Control Connection*
2. *Wind Speed Control Connection*
3. *Wind Triangle Rack*
4. *Point "B" of Wind Triangle*
5. *Point "C" of Wind Triangle*
6. *Point "A" of Wind Triangle*
7. *Air-Speed Rack*
8. *Air-Speed Follow-Up Motor*
9. *Air-Speed Receiver Teletorque Housing*
10. *Air-Speed Receiver Teletorque*
11. *Ground Speed Motor Adjusting Crank Handle*
12. *Constant-Speed Ground Speed Motor*
13. *Air-Speed Freezing Relay*
14. *Relative Wind Angle Differential*
15. *Track Transmitter Teletorques*
16. *Ground Speed Rack*
17. *Wind Drift Subtraction Differential*
18. *Ground Speed Motor Adjusting Crank*
19. *Ground Speed Drive Wheel*
20. *Ground Speed Teletorque Pinion—Take-Off Wheel*
21. *Ground Speed Take-Off Wheel Shaft*
22. *Ground Speed Teletorque Carriage*
23. *Ground Speed Transmitter Teletorque*

ing is introduced into the wind drift mechanism from the instrument take-off [section III, par. 3c (8)] through shaft (X) and gears (O) and (N), while wind direction from the instructor's hand crank is introduced through shaft (Z). The output of (RWAD) is applied to the wind bar through shaft (P) and gears (R), (R′), and (V′).

2. To further illustrate how the mechanical wind triangle works let it be assumed that the

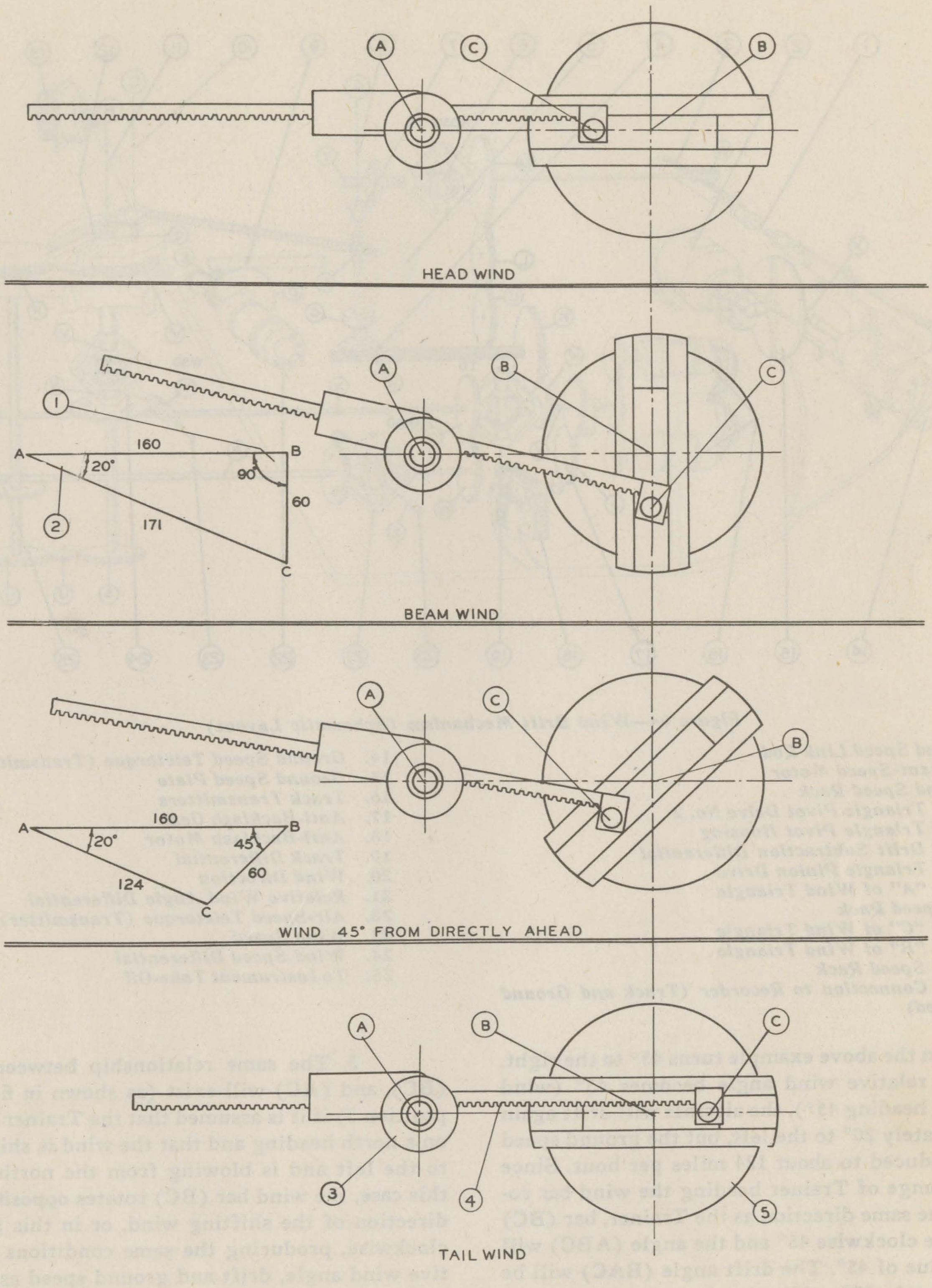

Figure 63—Wind Triangle Positions

1. ***Relative Wind Angle***
2. ***Drift Angle***
3. ***Wind Triangle Pivot***
4. ***Wind Triangle Rack***
5. ***Wind Bar***

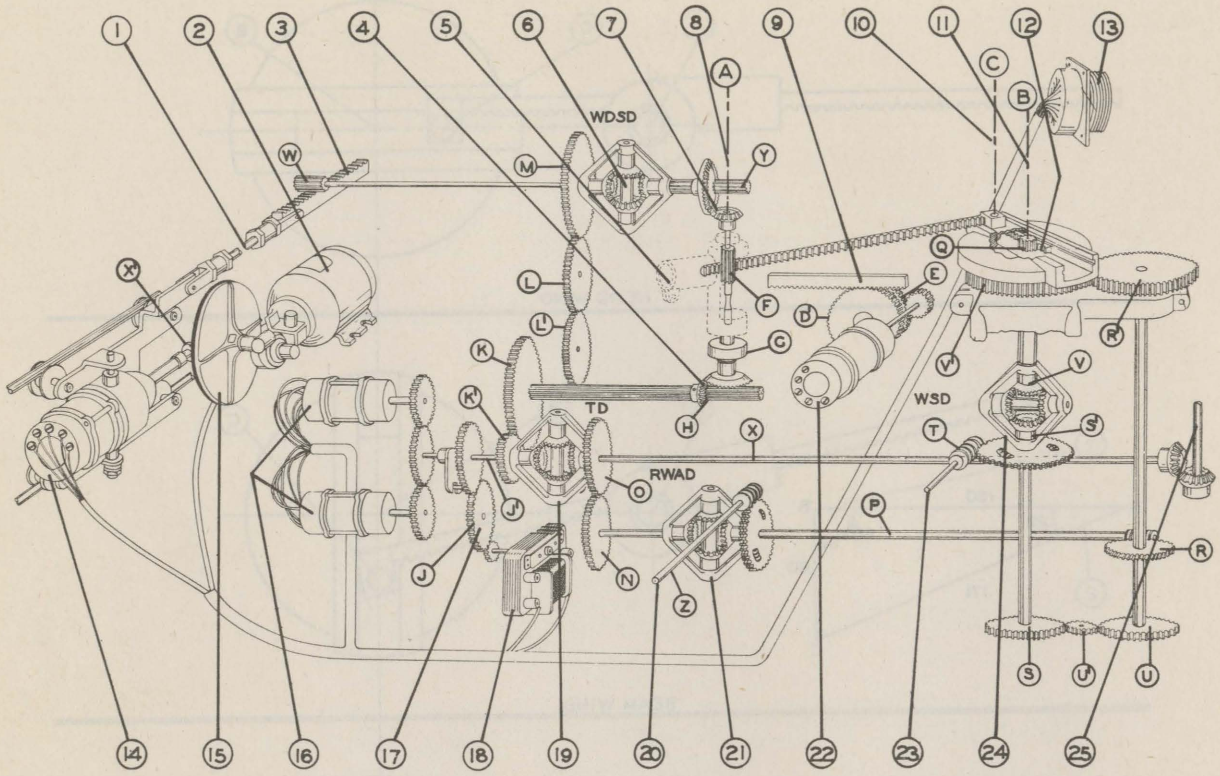

Figure 64—Wind Drift Mechanism (Schematic Layout)

1. *Ground Speed Link Rod*
2. *Constant-Speed Motor*
3. *Ground Speed Rack*
4. *Wind Triangle Pivot Drive No. 2*
5. *Wind Triangle Pivot Housing*
6. *Wind Drift Subtraction Differential*
7. *Wind Triangle Pinion Drive*
8. *Point "A" of Wind Triangle*
9. *Air-Speed Rack*
10. *Point "C" of Wind Triangle*
11. *Point "B" of Wind Triangle*
12. *Wind Speed Rack*
13. *Main Connection to Recorder (Track and Ground Speed)*
14. *Ground Speed Teletorque (Transmitter)*
15. *Ground Speed Plate*
16. *Track Transmitters*
17. *Anti-Backlash Gear*
18. *Anti-Backlash Motor*
19. *Track Differential*
20. *Wind Direction*
21. *Relative Wind Angle Differential*
22. *Air-Speed Teletorque (Transmitter)*
23. *Wind Speed*
24. *Wind Speed Differential*
25. *To Instrument Take-Off*

airplane in the above example turns 45° to the right. Now the relative wind angle becomes 45° (wind from 90°; heading 45°), the aircraft will drift again approximately 20° to the left, but the ground speed will be reduced to about 124 miles per hour. Since with a change of Trainer heading the wind bar rotates in the same direction as the Trainer, bar (BC) will rotate clockwise 45° and the angle (ABC) will have a value of 45°. The drift angle (BAC) will be approximately 20°, while the ground speed side of the wind triangle (AC) will have a length representing 124 miles per hour. (*See figure* 63, *position* 3.)

3. The same relationship between (AB), (BC), and (AC) will exist (as shown in figure 63, position 3) if it is assumed that the Trainer remains on a north heading and that the wind is shifted 45° to the left and is blowing from the northeast. In this case, the wind bar (BC) rotates **opposite** to the direction of the shifting wind, or in this instance clockwise, producing the same conditions of relative wind angle, drift and ground speed as though the aircraft has turned 45° to the right with the wind from the east. From this it may be seen that in spite of the fact that the heading side (AB) of the mechanical wind triangle is fixed in the wind

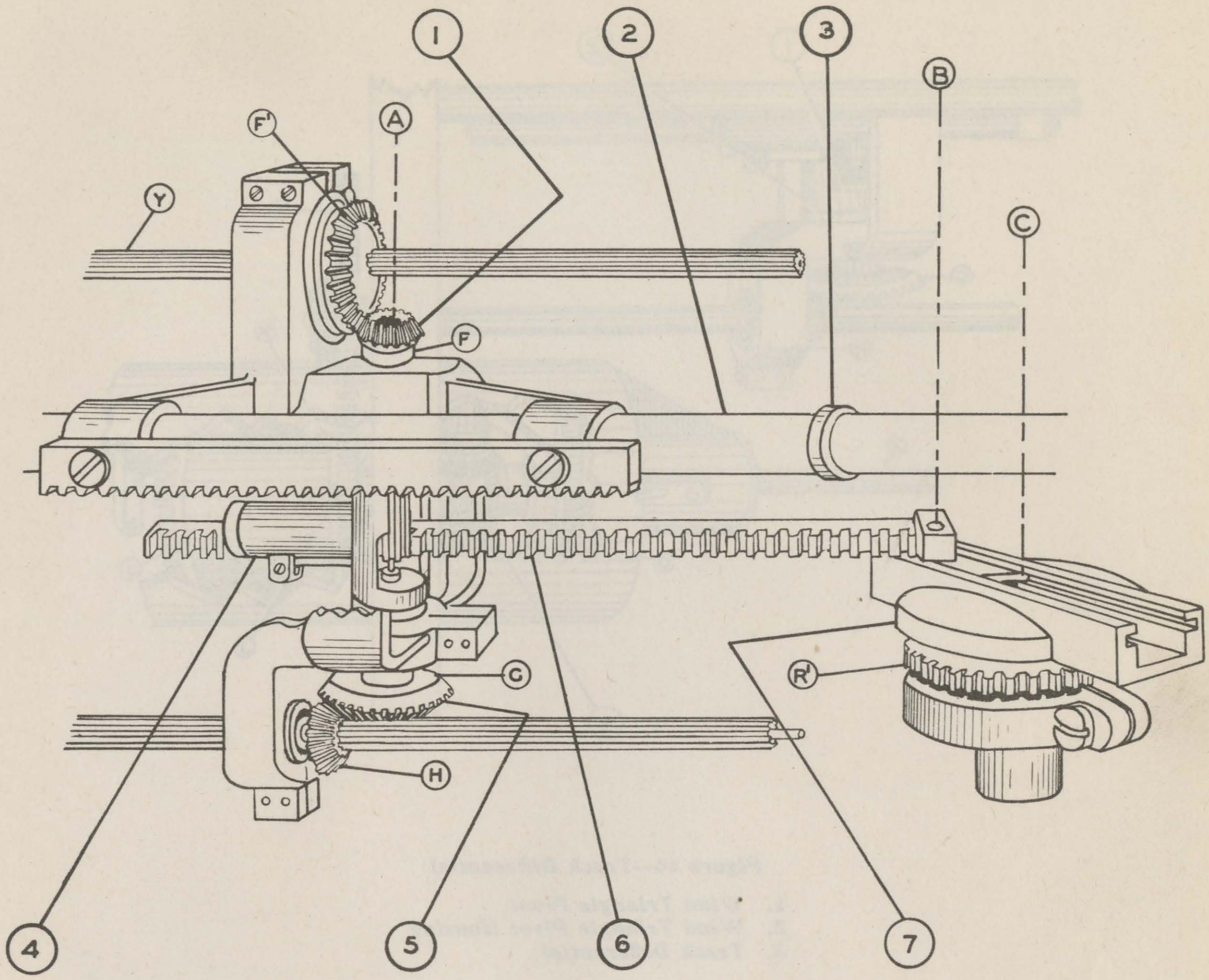

Figure 65—Main Wind Slide

1. *Wind Triangle Pinion Drive*
2. *Air-Speed Slide*
3. *Stop Collar*
4. *Wind Triangle Pivot Housing*
5. *Wind Triangle Pivot Drive*
6. *Wind Triangle Rack*
7. *Wind Bar*

drift mechanism, and regardless of the heading or wind direction, the correct relative wind angle and consequently correct drift angle and ground speed will be produced.

4. As the wind bar rotates, the wind triangle rack (AC) produces drift by rotating the wind triangle pivot housing, and produces ground speed by a sliding motion through the pivot housing, which turns the shaft of pinion (F). Two distinct drives are taken off the wind triangle rack; namely, the wind triangle pinion drive (No. 1) and the wind triangle pivot drive (No. 2).

(*d*) APPLICATION OF DRIFT AND GROUND SPEED MOVEMENT.

1. PIVOTING OR DRIFT MOVEMENT. (*See figure* 66.)

a. Track is one required output of the mechanism. Since the pivoting movement at the pivot housing produces drift, it is necessary, in order to obtain track, to add the heading to the drift algebraically. This is done at the track differential (TD). The drift angle is taken from the pivot housing at (G) through pinion (H), gears (K) and (J)

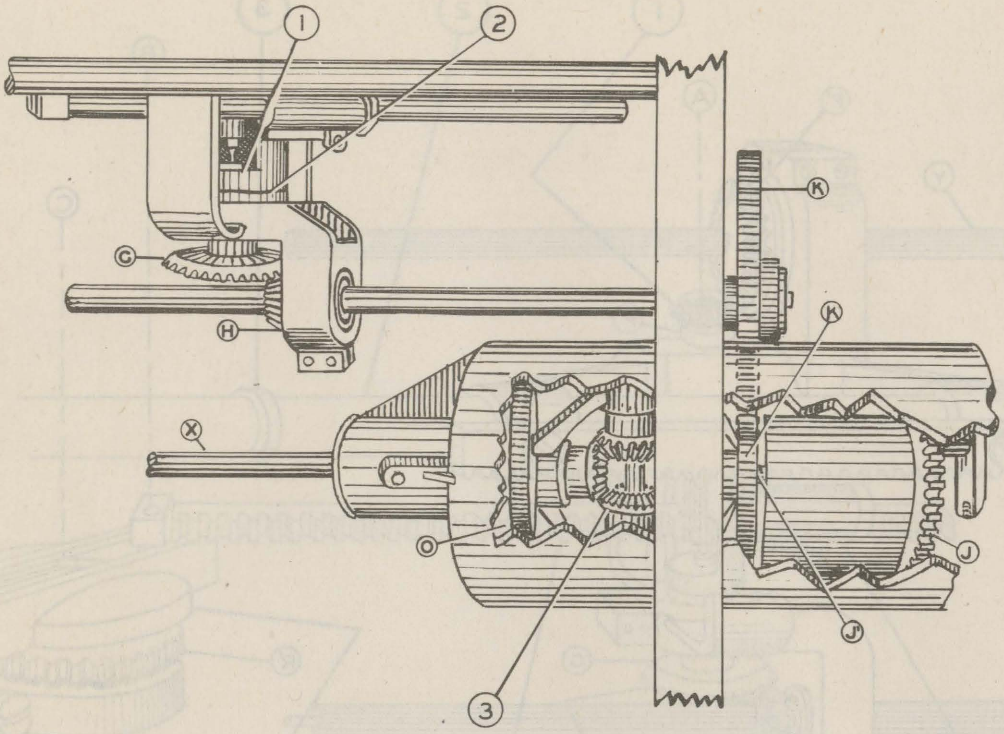

Figure 66—Track Differential

1. *Wind Triangle Pivot*
2. *Wind Triangle Pivot Housing*
3. *Track Differential*

to the differential housing while the heading is introduced from the instrument drive take-off through shaft (X). The two movements are coordinated by the differential, and the output, produced at shaft (J), is track.

b. The output shaft (J) of the differential drives the master gear of the transmitter teletorques (Selsyn type motors). These govern their receiver in the recorder and terrain projection plate drive, and control the direction of travel of the plate and the recorder. (Two transmitter teletorques are used to provide sufficient operating torque.)

NOTE

A motor is provided in order to remove backlash in the gear trains. This motor provides, through gear (J), constant torque in one direction although it may revolve indefinitely in either direction. The gearing in this manner is always under pressure in one direction and backlash can never come into play.

2. APPLICATION OF THE SLIDING OR GROUND SPEED MOVEMENT. (*See figure* 67.)

a. As was seen from the wind triangle, ground speed is derived from the sliding movement of the wind triangle rack along pinion (F). However, it will be observed that it is not possible to take the sliding motion along from pinion (F) at the wind triangle housing. When given sliding motion, the rack not only slides but pivots at the same time, producing an additional movement to the pinion (F), i. e., the movement which represents wind drift. The drift must be removed to obtain the ground speed alone. This is done by means

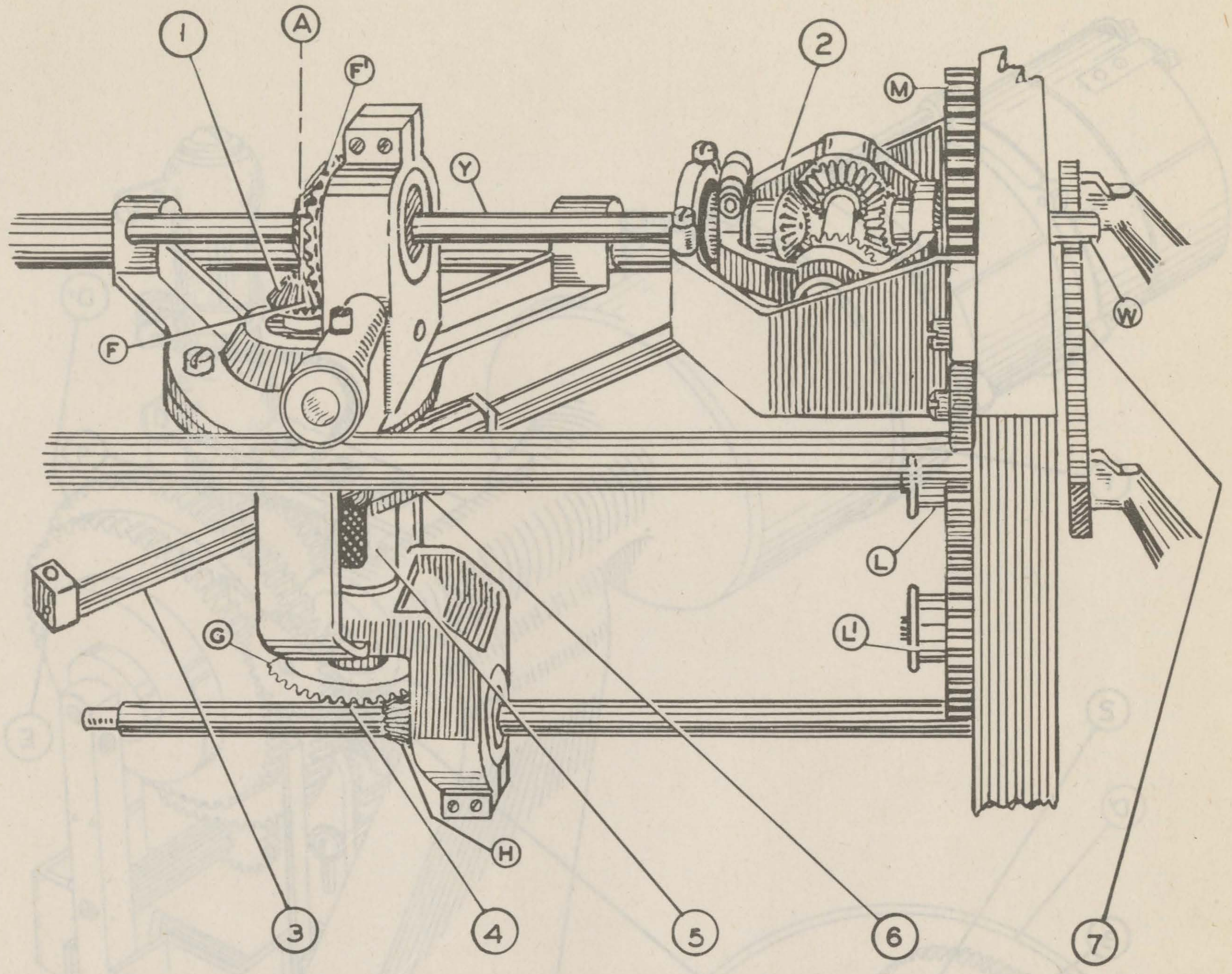

Figure 67—Wind Drift Subtraction Differential

1. *Wind Triangle Pinion Drive No. 1*
2. *Wind Drift Subtraction Differential*
3. *Wind Triangle Rack*
4. *Wind Triangle Pivot Drive No. 2*
5. *Wind Triangle Pivot*
6. *Wind Triangle Pivot Housing*
7. *Ground Speed Rack*

of the wind drift subtraction differential (WDSD). The combined pivoting and sliding movement of the wind triangle rack through shaft (Y) is led into one side of the differential. The pivoting motion alone is led into the other side of the differential through (G), (H), (L'), (L), and (M), to the housing of (WDSD). Thus, the output of the differential is the sliding plus the pivoting motion, less the pivoting motion, which equals the sliding or ground speed movement alone. The output is applied to pinion (W), moving the ground speed rack. This controls the position of the ground speed take-off wheel on the ground speed plate.

b. The ground speed movement is used to control the speed of the recorder over the chart, and also the speed of the projection plate drive.

(*e*) VARIATION OF AIR SPEED AND WIND SPEED.

1. AIR-SPEED CONTROL. (*See figures* 65 *and* 68.)

a. The air-speed component of the triangle is varied by altering the distance between the pivot (A) and the pivot of the wind bar (B). The wind bar pivot is fixed. The wind triangle pivot

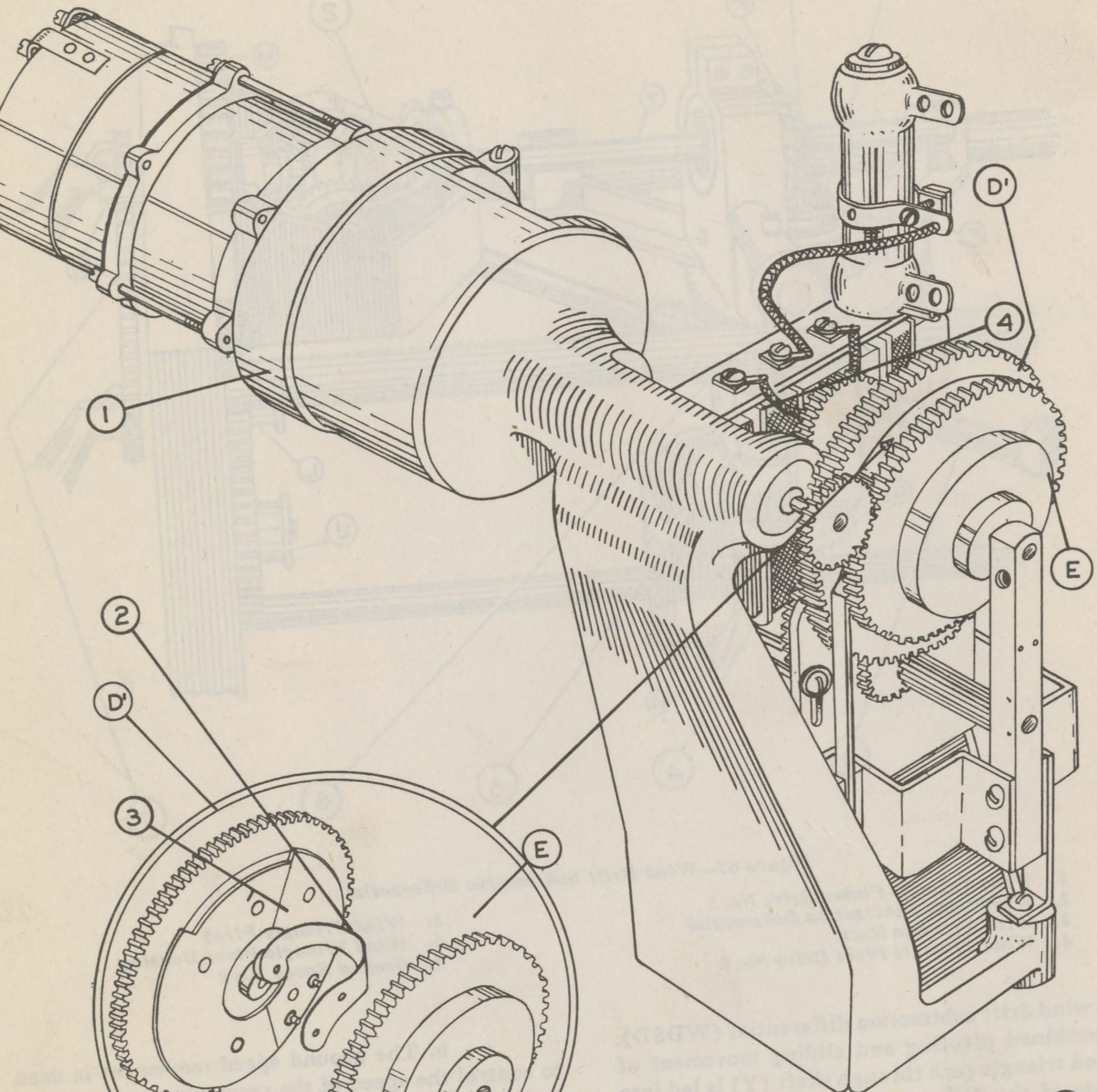

Figure 68—Air-Speed Follow-Up Assembly

1. *Teletorque (Air-Speed Receiver)*
2. *Contact Point*
3. *Plates*
4. *Two-Way Follow-Up Motor*
5. *Rotary Switch Assembly*

housing is mounted on a slide (air-speed slide) and it is free to move toward or away from the wind bar pivot. The pinions (H) and (F) are free to slide on their splined shafts.

b. The position of the wind triangle pivot on the air-speed slide is controlled by a two-way "follow-up" motor, which acts through gear (D′) and the air-speed rack (the rack being attached to the wind triangle pivot housing).

c. The direction and length of time that this "follow-up" motor runs is controlled by a rotary switch. One side of the rotary switch (the contact point) is attached to a gear wheel (E) which is geared to a teletorque. This teletorque motor is controlled from its master in the fuselage, which reacts to the throttle setting and attitude of the Trainer (air speed). The other side of the rotary switch, which consists of two plate sections, is attached to the disc (D). Contacting each plate section (one for clockwise, the other for counterclockwise rotation of the motor) is a brush which carries one side of the circuit to the "follow-up" motor. (The periphery of each plate is cut in the form of a notched cam. This cam operates contacts in the motor circuit which open when the limit of motor travel in either direction has been reached.)

d. When the teletorque rotates (due to a change in air speed), the contact point on the gear (E) makes contact with one of the plates attached to the disc on pinion (D). This completes the circuit to the follow-up motor which rotates and turns the pinion (D). This pinion drives the rack and the wind triangle pivot housing attached to it. The disc with the attached plates also rotates with the pinion, and when the contact point on the gear wheel (E) bridges the plates, the motor stops.

2. WIND SPEED CONTROL. (*See figure 69.*)

a. Wind speed is varied by altering the distance between (B) and (C). The slotted wind bar accommodates a rack which slides in the bar. The rack is driven by pinion (Q) in the center of the wind bar. As the pinion revolves, the crankpin at (C) moves toward or away from the center of the wind bar, decreasing or increasing the wind speed.

b. However, if the drive to the rack was direct, the setting of the crankpin would be disturbed whenever the wind bar revolved. [The pinion (Q) at (B) remaining stationary and the rack rotating about it, causes the pinion (Q) to drive the rack.] To allow for the fact that the wind bar revolves with the Trainer heading, a differential is provided, which turns pinion (Q) at (B) in the same direction as that in which the wind bar is revolving.

c. It can be seen (figure 69) that when the wind bar rotates due to change of Trainer heading or wind direction (manual control movement), the output of differential (RWAD) to (R), or (R′), and (V′) is transferred also by gears (U), (U′), and (S) to pinions (S′) and (V) of the wind speed differential, to pinion (Q) at center (B). Thus the rotation of the Trainer has no effect on the setting of the crankpin. The wind speed is set by hand through worm gear (T) and the secondary drive of the differential to the pinion (Q) at (B). The wind may be varied from zero [when the crankpin at (C) is directly over the center (B)] to 60 units when the rack is fully extended and the pin is at the greatest possible distance from (B). Wind speed units are represented as knots or mph depending on the ground speed take-off wheel used.

(*f*) APPLICATION OF THE WIND DRIFT MECHANISM OUTPUT TO THE RECORDER AND TERRAIN PROJECTION PLATE.

1. THE WIND DRIFT MECHANISM OUTPUT.—This output consists of two movements; one represents change of track, the other represents change of ground speed. The movements are transmitted by means of teletorques to the recorder and to the terrain projection plate. The track movement is applied to receiver teletorques by transmitter track teletorques in the wind drift mechanism, governing the direction of travel, or track, of the recorder and projection plate. A constant speed electric motor indirectly provides the drive for movement of the recorder and of the plate. It is necessary to vary the speed output of this drive in accordance with the ground speed output of the wind drift mechanism.

2. GROUND SPEED DRIVE. (*See figure 64.*)

a. The ground speed drive is mounted outside the main body of the wind drift mechanism and consists of a rotating plate driven by a constant speed motor, with a take-off wheel (X′) mounted at right angles to the plate and making contact with its surface. The surface of the plate is covered with rubber.

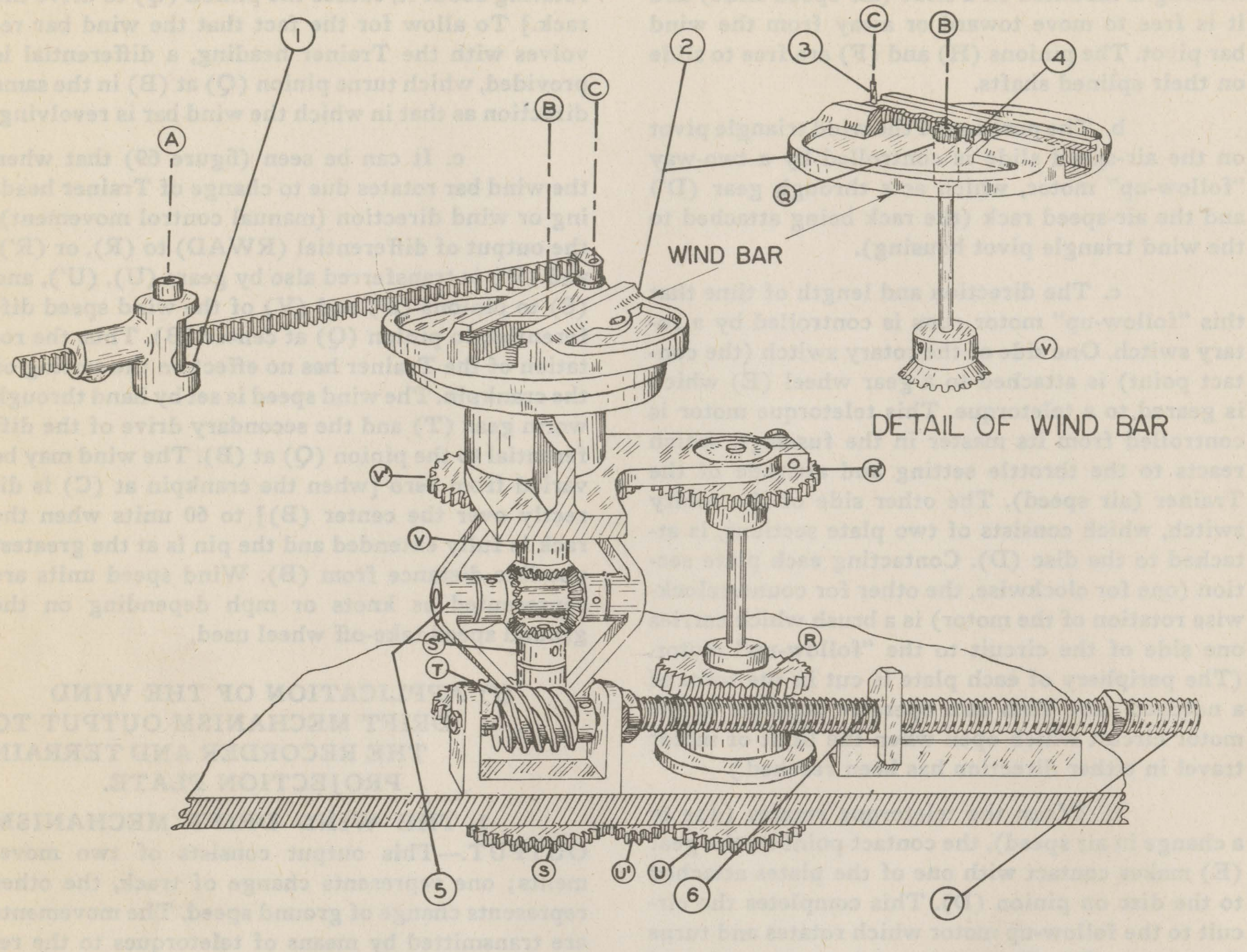

Figure 69—Wind Speed Control and Detail of Wind Bar

1. *Wind Triangle Pivot*
2. *Wind Bar*
3. *Crank Pin*
4. *Wind Speed Rack*
5. *Wind Speed Differential*
6. *Stop*
7. *Wind Speed Control Connection*

b. Two ground speed take-off wheels which fit on the end of the teletorque drive shaft are provided. One is a standard or statute mile wheel (1.5750 inches in diameter) and the other is a nautical mile wheel (1.3390 inches in diameter). The nautical mile wheel is easily identified by the word "knots" stamped on it. Either wheel may be used, depending on the desired results to be obtained. These results will differ in units only; that is, statute miles per hour or knots as the case may be. The air-speed indicator and the wind speed input will read either knots or statute miles per hour depending on the wheel used. Consequently, the terrain projection plate and recorder rate of travel will be in units of the particular wheel used. No matter which wheel is used, the units will be consistent throughout.

c. While the take-off wheel is in operation, a spring on the arm holds it against the surface of the ground speed plate with a light pressure. The teletorque carriage is adjustable, toward and away from the plate, so that with different size wheels, the drive shaft may be adjusted parallel to the face of the plate. The take-off wheel (X′) drives the ground speed transmitter teletorque which is mounted on a carriage so that it may be moved toward or away from the center of the rotating plate. In this way, the speed at which the take-off wheel is driven varies. When the take-off wheel is

at the center of the disc, its rotation is zero. As it is moved away from the center, its speed is increased until it reaches a maximum at the rim of the plate.

d. The speed at which the ground speed teletorque is driven is varied by moving the carriage by means of gear (W), the ground speed rack, and the adjustable link rod. The rotation of the transmitter ground speed teletorque is followed by its receiver teletorques in the recorder and in the projection plate drive. In this way, both are driven at the correct ground speed.

(*g*) SUMMARY.

1. THE FOUR RACKS.—The wind drift mechanism contains four racks:

a. WIND TRIANGLE RACK.—Through the wind triangle rack, the wind triangle pivot receives the wind drift movement, and the wind triangle pinion receives the ground speed movement.

b. GROUND SPEED RACK.—The rack is driven by a pinion which moves in proportion to the value of the changing ground speed of the simulated aircraft. The rack drives the carriage upon which the master ground speed teletorque is mounted.

c. WIND SPEED RACK.—The wind speed rack is the unit by which the length of the wind speed vector is varied. Set in the wind bar, it is driven by a pinion with a special provision being made for the wind bar to rotate without disturbing the setting of the rack.

d. AIR-SPEED RACK.—The air-speed rack is driven by the air-speed "follow-up" motor and determines the value of the air-speed side of the triangle.

2. THE FOUR DIFFERENTIALS.—The wind drift mechanism contains four differentials. The following is a summary of their uses:

a. TRACK DIFFERENTIAL. — The drives: heading (from the instrument take-off) and drift angle (from the wind triangle pivot). The output: track (relayed to master teletorque).

b. WIND DRIFT SUBTRACTION DIFFERENTIAL.—The drives: ground speed plus wind drift (sliding and pivoting movement of wind triangle rack), and wind drift (wind triangle pivot). The output: ground speed (through position of the ground speed take-off wheel).

c. WIND SPEED DIFFERENTIAL.—The drives: wind bar rotation and wind speed control. The output: wind speed relayed through the wind speed rack to wind speed crankpin.

d. RELATIVE WIND ANGLE DIFFERENTIAL. — The drives: Trainer heading (from instrument take-off) and wind direction control. The output: relative position of heading to wind direction (relative wind angle).

(4) BOMB HIT TIMER. (*See figure* 183.)

(*a*) TIME OF FALL.—When the bomb release switch is closed, it sets into operation an automatic timing mechanism. This unit times the interval between release and impact of the bomb. A dial graduated from zero seconds to 55 seconds enables the instructor to set the desired time interval on the unit by a control knob and pointer. The correct number of seconds for the time of fall for a given type of bomb at different heights above terrain while flying at different speeds, is obtained from a chart which shows the required time. The time of fall in the Trainer is artificial and not equal to the time of fall under the same conditions as experienced in actual practice. [See section VI, par. 1*b* (8).]

(*b*) PRINCIPLE OF OPERATION.—The control knob on the bomb hit timer is connected to one side of a switch (contact point). This contact point is moved in an arc by the knob. When the bomb release switch is closed, a synchronous motor (telechron) is started. This rotates a second contact point from a zero position to the first contact point, the operation taking the same number of seconds as were set into the unit by the control knob setting on the dial. Relays are operated when the points meet, one relay turning on the light in the hit projector; and the other, operated through another rotary switch arrangement, keeps it on for two seconds. At the end of the two-second interval, a spring return resets the mechanism for the next operation.

(5) ARTIFICIAL MAGNETIC NORTH.—Both true and magnetic north are determined artificially in the Trainer. "True north" is fixed by the position of the celestial dome rail with the north-south line (meridian) lying in the plane of the curved center line of the rail. A magnetic compass is used by the pilot and the navigator and means are provided for keeping them in the correct relation to the artificial "true-north." A magnetized bar is mounted above the compass on a small shaft which is connected by a system of flexible and rigid shafts

to a drive (heading drive) in the base of the Trainer tower. As the tower revolves, the bar is driven against the direction of rotation of the tower so that it constantly points in the same direction (artificial magnetic north). The relation between true and magnetic north is established by setting the bar to point the desired number of degrees east or west of the dome rail. The control is mounted directly above the wind drift mechanism on the tower base section, and is a differential coupling in the compass artificial north magnet drive shaft from the instrument take-off to the compass. The adjustment scale is graduated in degrees and allows for 180° variation east or west, and a knurled setscrew is provided to lock the coupling in position when the desired variation has been set on the scale.

(6) TERRAIN PROJECTION SCREEN. (*See figures 70 and 71.*)

(*a*) The projection screen, mounted on the Trainer tower directly below the navigator's compartment, is made of doped fabric stretched on a frame of welded stainless-steel sheet.

(*b*) The entire screen and frame are supported by two welded steel tubes. Each tube is bolted to the screen frame, one on either side, at a point approximately two-thirds of the distance from the back edge, and each one is also bolted to the front leg of the tower by means of an adjustable clamp. The screen frame is bolted along its back edge by means of two welded eyebolts, to a welded bracket mounted on each of the two front tower legs.

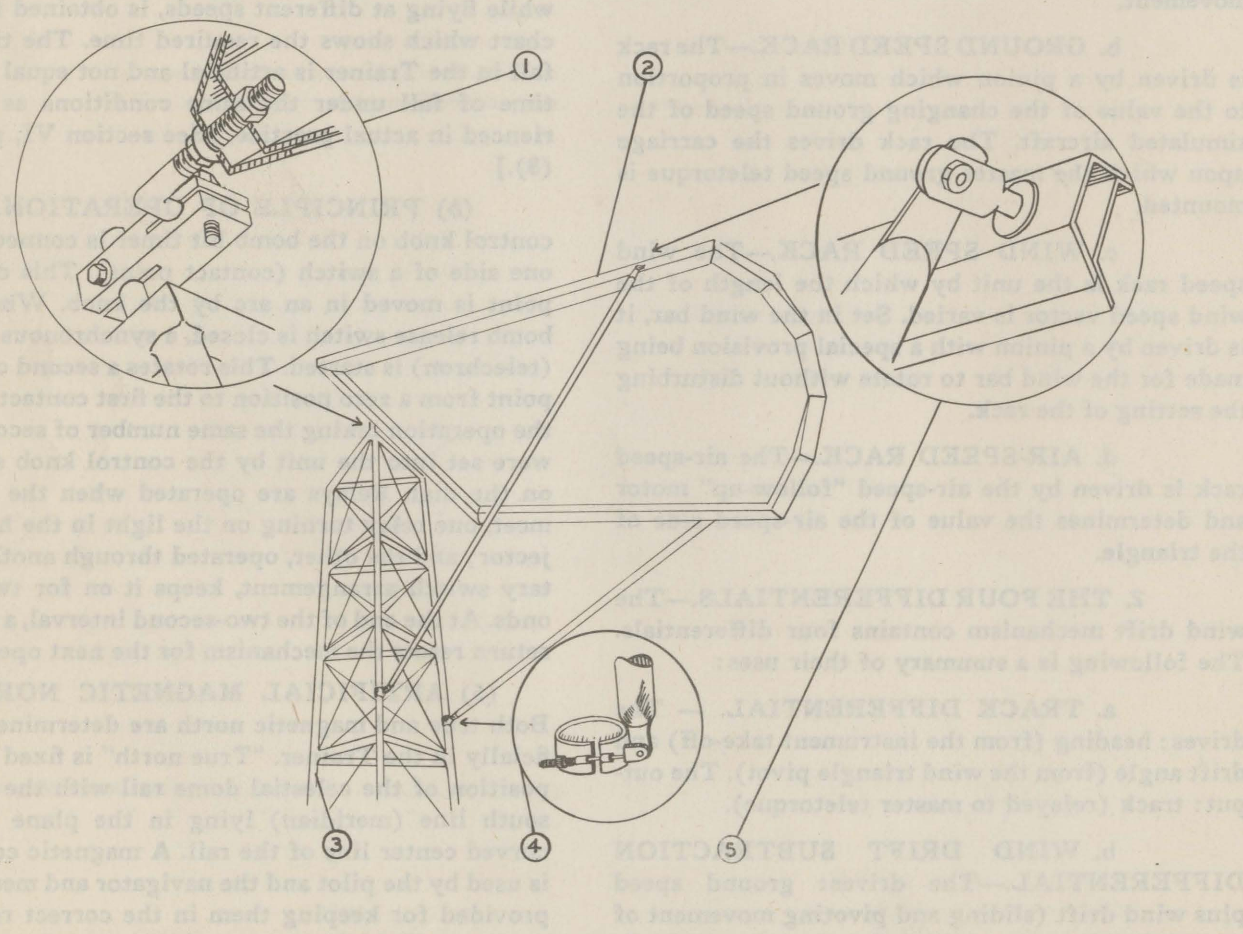

Figure 70—Projection Screen

1. *Top Tower Bracket*
2. *Projection Screen*
3. *Fuselage Tower*
4. *Lower Tower Clamp*
5. *Screen Support Bracket*

(*c*) A plastic grommet with a 6-inch inside diameter, is secured on the screen fabric. It is positioned to allow the cable to the front pitching bellows to have maximum movement in all directions.

(*d*) Attached to the projection screen is a horizon curtain assembly. It consists of a framework of 5/8 inch and 1/2 inch welded aluminum tubes, clamped together and fastened to the screen frame by the use of adapters. The black fabric screen or curtain is hung from this tube support rail to form a light-proof shield encircling the projection screen and extending upward from it to a height of approximately 5 feet.

(*e*) The projection screen is 10 feet long by 10 feet across the front, and approximately 7 feet across the back. The center of the projection image is 6 feet 7 inches from the front of the screen.

(7) MAIN BELLOWS. (*See figure 72.*)

(*a*) BANKING MOTION.—Banking motion is obtained by use of two of the four large bellows located underneath the fuselage and secured

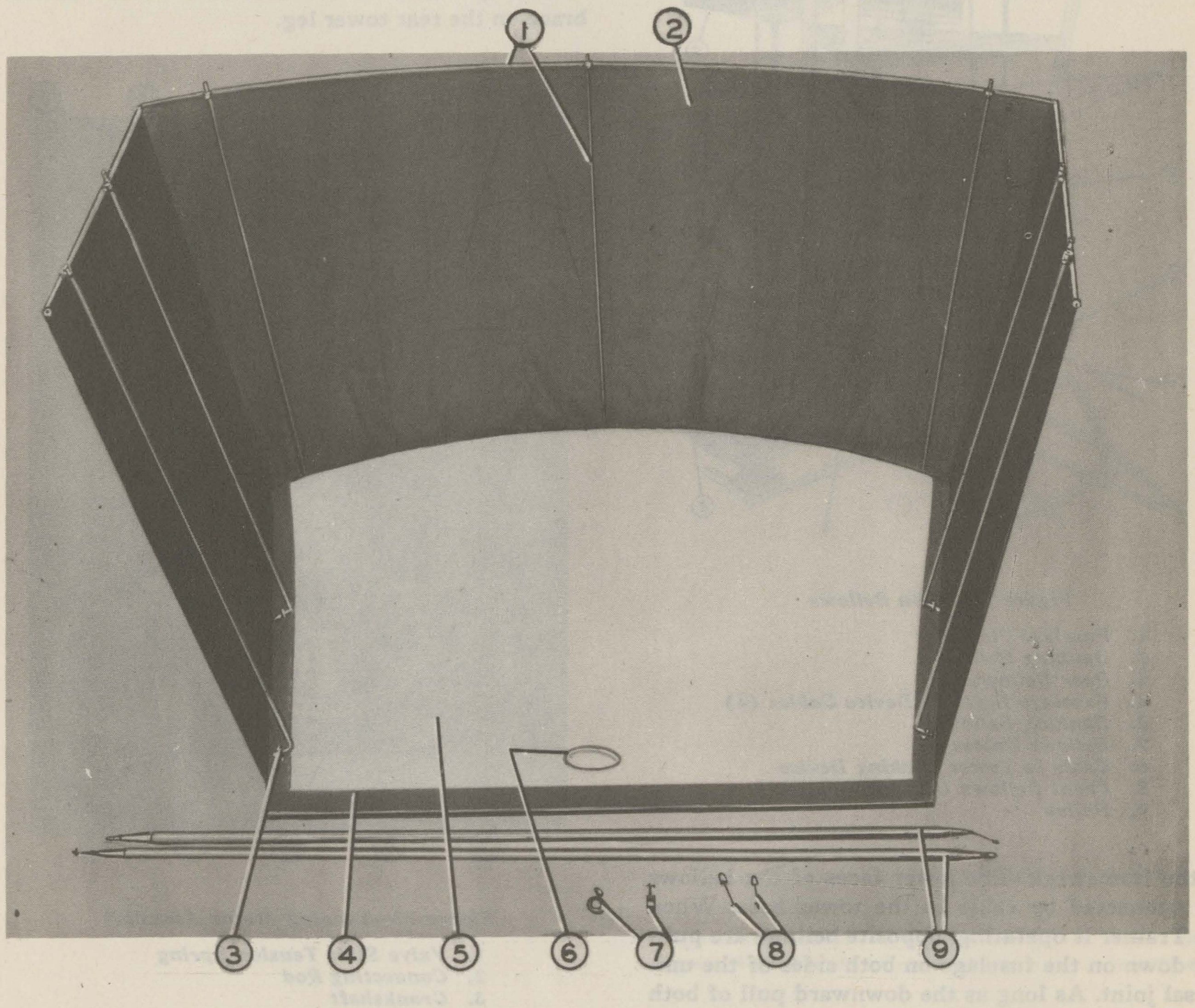

Figure 71—Projection Screen, Horizon Curtain Assembly

1. ***Horizon Curtain Frame***
2. ***Horizon Curtain***
3. ***Horizon Curtain Frame Adapter***
4. ***Projection Screen Frame***
5. ***Projection Screen***
6. ***Grommet***
7. ***Screen Frame Support Clamps***
8. ***Screen Frame Eyebolts***
9. ***Screen Frame Tube Supports***

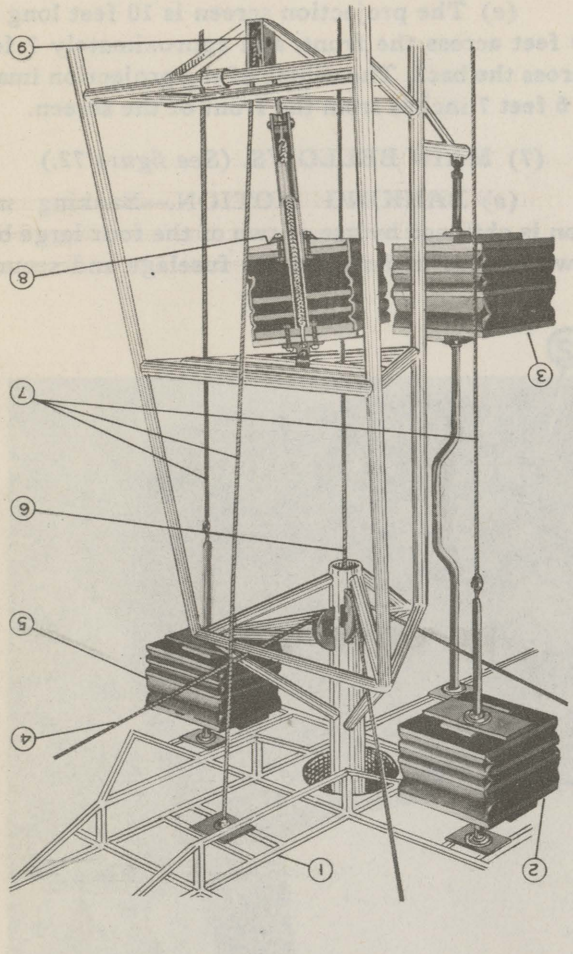

Figure 72—Main Bellows

1. *Fusulage Floor*
2. *Banking Bellows*
3. *Rear Bellows*
4. *Fuselage Leveling Device Cables (4)*
5. *Banking Bellows*
7. *Bellows Cables*
6. *Cable to Tower Locking Device*
8. *Front Bellows (Cutaway)*
9. *Pulley*

to the framework. The lower faces of the bellows are connected by cable to the tower base. When the Trainer is operating, opposite bellows are pulling down on the fuselage on both sides of the universal joint. As long as the downward pull of both bellows is equal, the Trainer remains motionless laterally. Vacuum is supplied to the two banking bellows through a two-way valve (aileron valve) which is linked to the control column. By operating the aileron valve with the control wheel, vacuum can be applied to one bellows while atmospheric pressure is applied to the other. Thus, the fuselage is caused to bank left or right.

(*b*) PITCHING MOTION.—This motion is obtained with the front and rear bellows. These bellows are located on the longitudinal axis, one in front of, and the other behind the universal joint. They operate the same as the banking bellows and are controlled by the elevator valve which is linked to the control column. The front bellows is attached to a properly braced pulley support on the tower pedestal tube, while the rear bellows is attached by means of a U-bolt to a welded anchor brace on the rear tower leg.

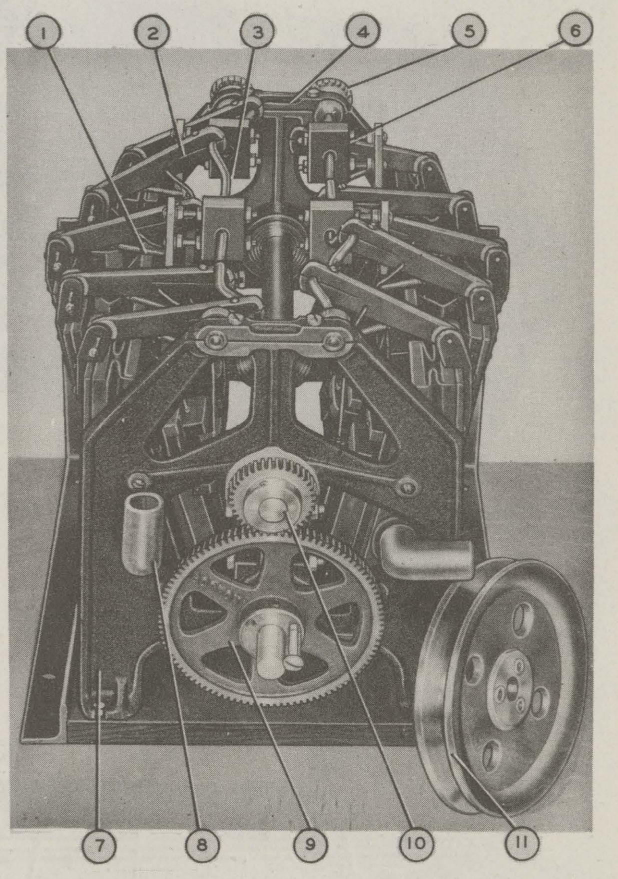

Figure 73—Turning Motor Assembly

1. *Valve Slide Tension Spring*
2. *Connecting Rod*
3. *Crankshaft*
4. *Crankshaft Bearing Clamp*
5. *Crankshaft Drive Gear*
6. *Crankshaft Bearing*
7. *Turning Motor End Plate*
8. *Manifold Elbow*
9. *Top Turning Motor Shaft Gear*
10. *Front Shaft Top Gear*
11. *Turning Motor Belt Pulley*

c. COUNTERBALANCE FRAME ASSEMBLY.

(1) FRAME CONSTRUCTION.—The frame viewed from above is diamond shaped in appearance with one of the end points (front) cut off, and is bolted to the main bearing around which it revolves. The tower and fuselage are mounted on one end, with the counterbalance weights and the vacuum equipment on the other end.

(2) WEIGHTS.—The weights consist of a number of circular discs placed on a bracket which is mounted on the under side of the frame.

(3) ROTATION OF THE TRAINER TOWER.—The tower is rotated by two turning motors. The drive is taken off each motor pulley and transmitted to the counterbalance frame by two leather belts, one for each turning motor. The motors are mounted on the counterbalance frame, below the tower, and revolve with it. The power transmission belts pass around fixed pulley grooves at the base of the main bearing hub, through the belt tightener assembly, and around the drive pulley of each motor.

(a) TURNING MOTORS. (*See figures* 73 *and* 74.)—The two turning motors operate together

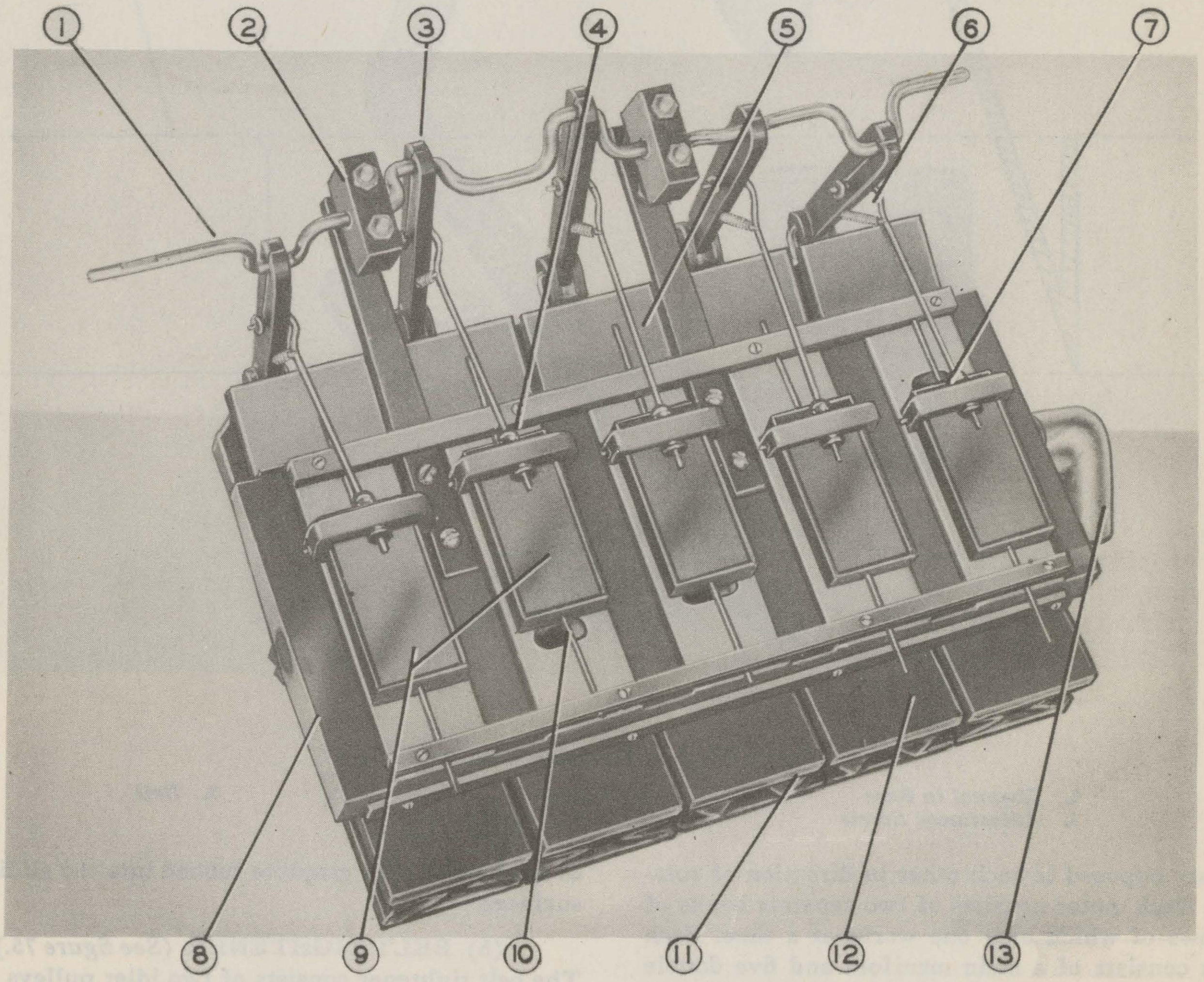

Figure 74—Turning Motor Valve Bank

1. *Crankshaft*
2. *Crankshaft Bearings*
3. *Connecting Rod*
4. *Plastic Adjusting Nuts*
5. *Valve Slide Rod*
6. *Valve Slide Tension Spring*
7. *Port*
8. *Valve Manifold*
9. *Sliding Bypass Valves*
10. *Port*
11. *Bellows Fabric*
12. *Bellows*
13. *Manifold Elbow*

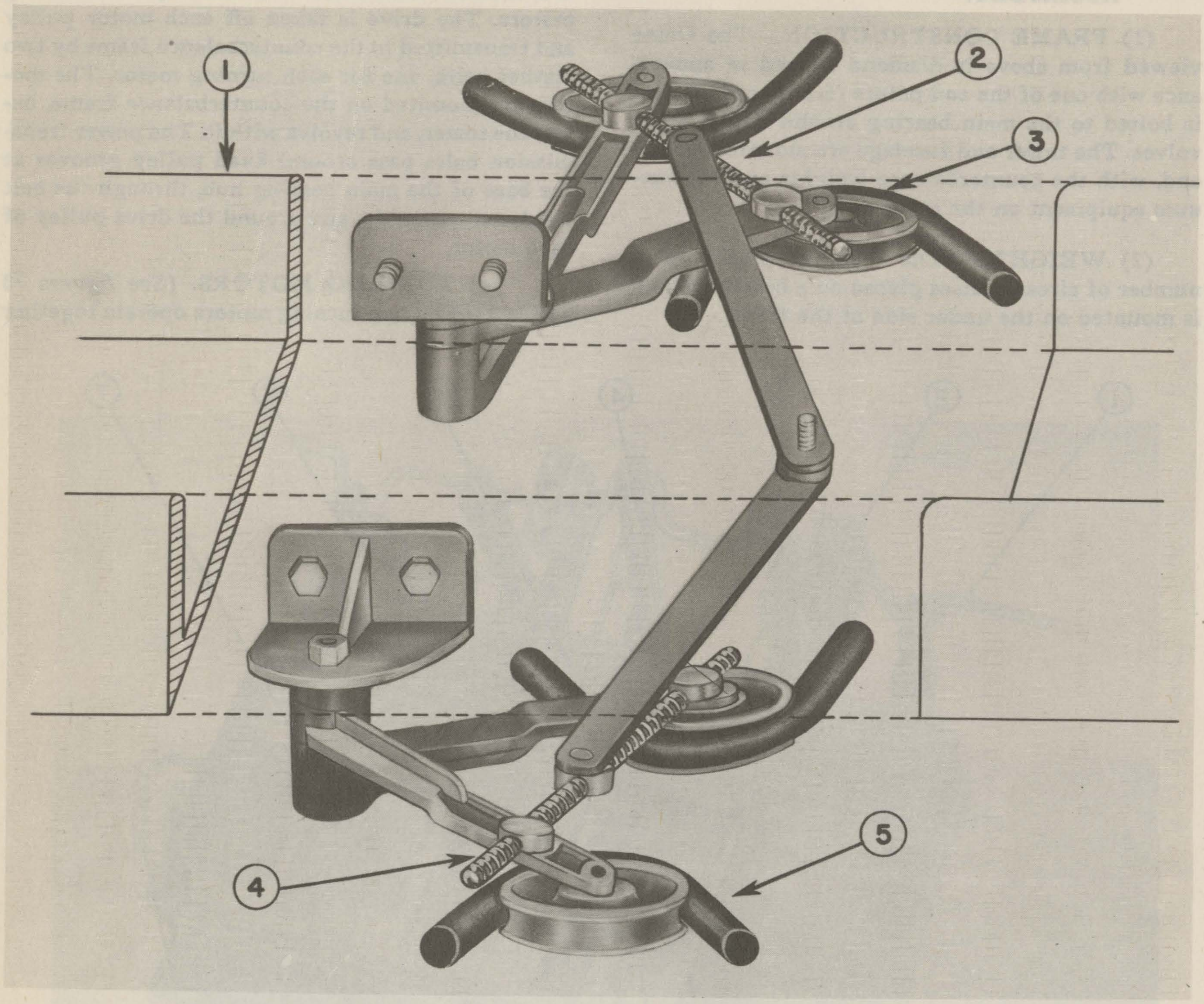

Figure 75—Belt Tightener Assembly

1. *Channel in Base*
2. *Adjustment Screw*
3. *Pulley*
4. *Adjustment Screw*
5. *Belt*

but are opposed to each other in direction of rotation. Each motor consists of two separate banks of bellows of which only one works at a time. Each bank consists of a main manifold and five double bellows which are connected to a crankshaft by connecting rods. The bank is fitted with sliding valves which time the action of the bellows. The crankshafts of both banks are geared to the same reduction gear unit which terminates in a pulley for the leather belt. The seats and sliding valves are made of hard wood with graphite rubbed into the sliding surfaces.

(*b*) BELT TIGHTENER. (*See figure* 75.)—The belt tightener consists of two idler pulleys attached to an adjustable scissor-type mount. Closing the "V" by means of the screws increases the belt tension.

(4) TOWER LOCKING DEVICE. (*See figure* 76.)—This unit is a plunger, mounted at the

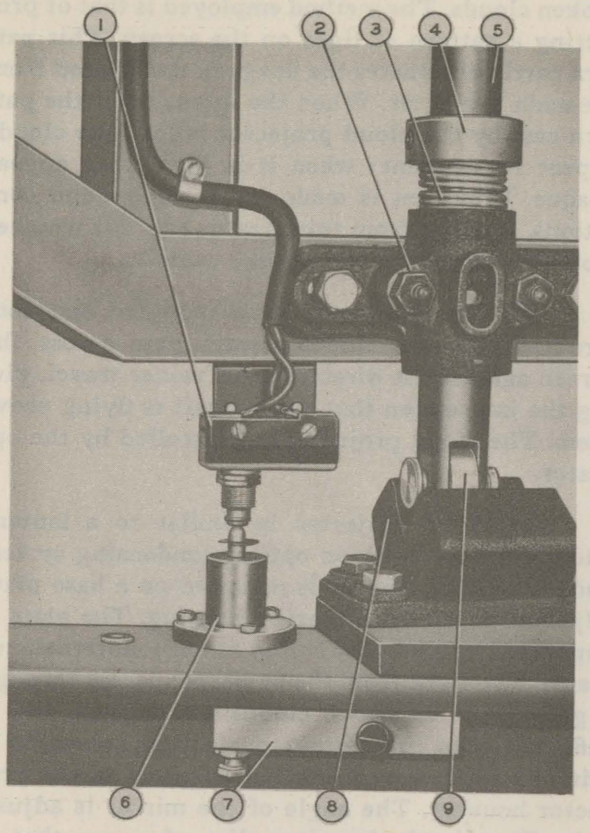

Figure 76—Tower Locking Device

1. *Fuselage Door Lock Micro-Switch*
2. *Tower Locking Device Bearing*
3. *Locking Device Spindle Spring*
4. *Locking Device Spindle Spring Stop*
5. *Tower Locking Device Spindle*
6. *Micro-Switch Actuating Plunger Housing*
7. *Micro-Switch Actuating Plunger*
8. *Locking Device Detent*
9. *Locking Device Spindle Roller*

bottom of the tower, which engages a grooved lug mounted on the Trainer base. The plunger is operated by a lever arm attached to a cable which is connected to the leveling device drum in the fuselage. When the Trainer is being leveled, the drum winds in the lever cable and lowers the plunger. When the Trainer is in operation, the plunger is held clear of the lug by a spring.

(5) TURBO-COMPRESSOR (Turbine). (*See figure* 77.)

(*a*) USE.—This machine has been carefully balanced and tested at the factory to insure proper operation. Service and maintenance instructions on this machine must be strictly adhered to for maximum operating efficiency and long life.

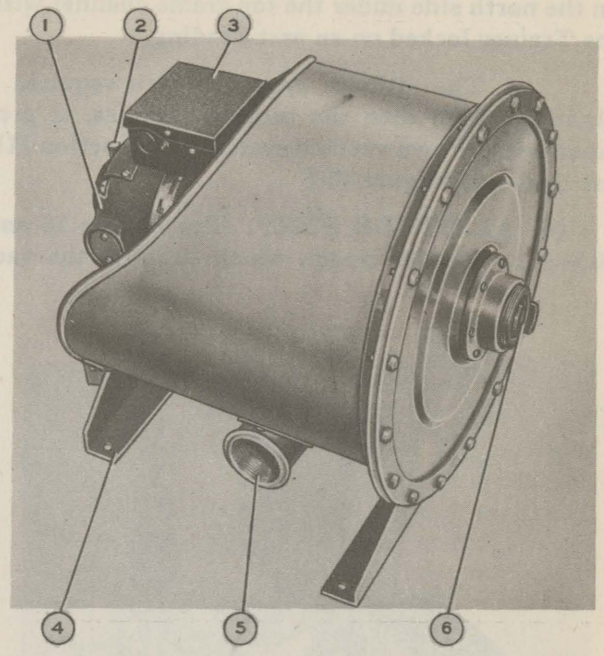

Figure 77—Turbine

1. *2 HP Motor*
2. *Grease Cup*
3. *Motor Filter Box*
4. *Mounting Flange*
5. *Exhaust*
6. *Intake*

(*b*) DESCRIPTION.

1. The turbine is designed to operate on a line voltage of 220, and to produce vacuum equivalent to between 8 and 9 inches Hg. Under normal operation, with a standard air-bleed (5/16 inch) in the intake, the turbine will draw 30 cubic feet of air per minute. When testing the turbine for maximum output, make sure that the proper voltage is being applied, as the vacuum output drops rapidly with a decrease in voltage.

2. The vacuum turbine is mounted on the tower base (figure 58), and is driven by a 2 HP single-phase 220-volt universal motor. A vacuum manifold runs above the counterbalance frame and connects the turbine with the rear tower leg. The turbine supplies the main control valves and the gyro instruments in the fuselage with partial vacuum.

3. Voltage supply for the turbine and altitude pump comes from the tower junction box (3 wires), into the turbine junction box (220 volts—3 wires). The turbine taps off from the 220-volt supply and the altitude pump leads tap off from the 110-volt supply. These junction boxes are mounted

on the north side under the top frame channel with the Trainer locked on an east heading.

4. The altitude system, which requires a higher vacuum than the turbine supplies, is provided with its own vacuum system. [See section III, par. 2*h*(1) and figure 43.]

(6) ALTITUDE PUMP. (*See figures* 78 *and* 79.)—The altitude pump, which supplies the vacuum used to simulate altitude, is located on the front right-hand corner of the counterbalance frame. The pump is driven by a 1/4 HP electric motor and has a maximum output of approximately 24.5 inches Hg of vacuum. A relief valve is used to limit the vacuum output of the pump to 14 inches Hg of vacuum.

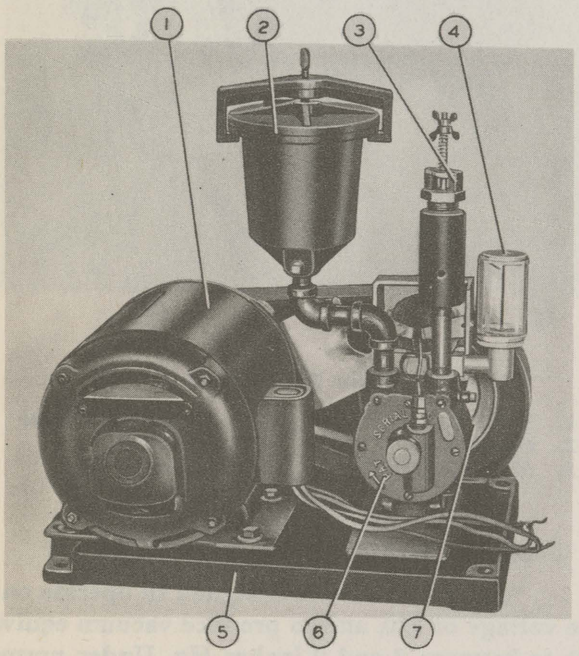

Figure 78—Altitude Pump

1. *Altitude Pump Motor*
2. *Altitude Pump Exhaust Filter*
3. *Pressure Relief Valve*
4. *Automatic Oiler*
5. *Pump Base Mounting*
6. *Altitude Pump*
7. *Pump Belt Pulley*

(7) CLOUD PROJECTOR. (*See figure* 80.)

(*a*) The cloud projector is provided to give the impression that the observer is flying above the overcast, or that the terrain is partly hidden by broken clouds. The method employed is that of projecting a pattern of light on the screen. This pattern partly eliminates the image of the ground from the main projector. When the intensity of the pattern cast by the cloud projector is low, the clouds appear transparent; when it is high, they appear opaque. Provision is made for various cloud conditions, ranging from thin stratus and fair weather clouds to congested and opaque cumulus.

(*b*) The projector is so mounted and constructed that the clouds always pass across the screen against the direction of Trainer travel, giving the impression that the aircraft is flying above them. The cloud projector is controlled by the operator.

(*c*) This projector is similar to a lantern slide projector, with an optical condensing system and a focusing lens. It is mounted on a base plate adjacent to the main bearing housing. The plate is supported by a bracket bolted to the counterbalance frame. The light from the projector passes through a glass plate on which clouds are painted, and is reflected onto the terrain projection screen by a mirror mounted on a bracket attached to the projector housing. The angle of the mirror is adjustable. The cloud plate is a disc of pyrex that is mounted in a felt-covered metal guide and rests on two rubber-rimmed wheels. One wheel drives the plate while the other idles. An electric fan motor mounted beside the projector provides the drive. The disc may be slipped in and out of the metal holder at will (discs with different cloud formations being provided). A fan is mounted beside the projector for cooling purposes and is driven by the same motor as the disc. The motor is a constant speed 1/400 HP, 1600 armature rpm reduced to a shaft output of 2.28 rpm. A removable case is provided to protect the whole assembly from dust.

(8) INSTRUMENT DRIVE ASSEMBLY. (*See figure* 81.)—The wind drift mechanism, compass, and radio receiver loop must all be affected by changes in Trainer heading. This is accomplished by interconnecting these units through the instrument drive assembly. Trainer heading is taken from a large internally cut ring gear (A) through an anti-backlash pinion gear (B) in the base of the Trainer main bearing housing. The gear (A) is mounted on this housing (stationary), and the pinion (B) on a shaft extending from the instrument take-off which revolves with the hub. Pinion gear (B) rolls around gear (A) and transfers

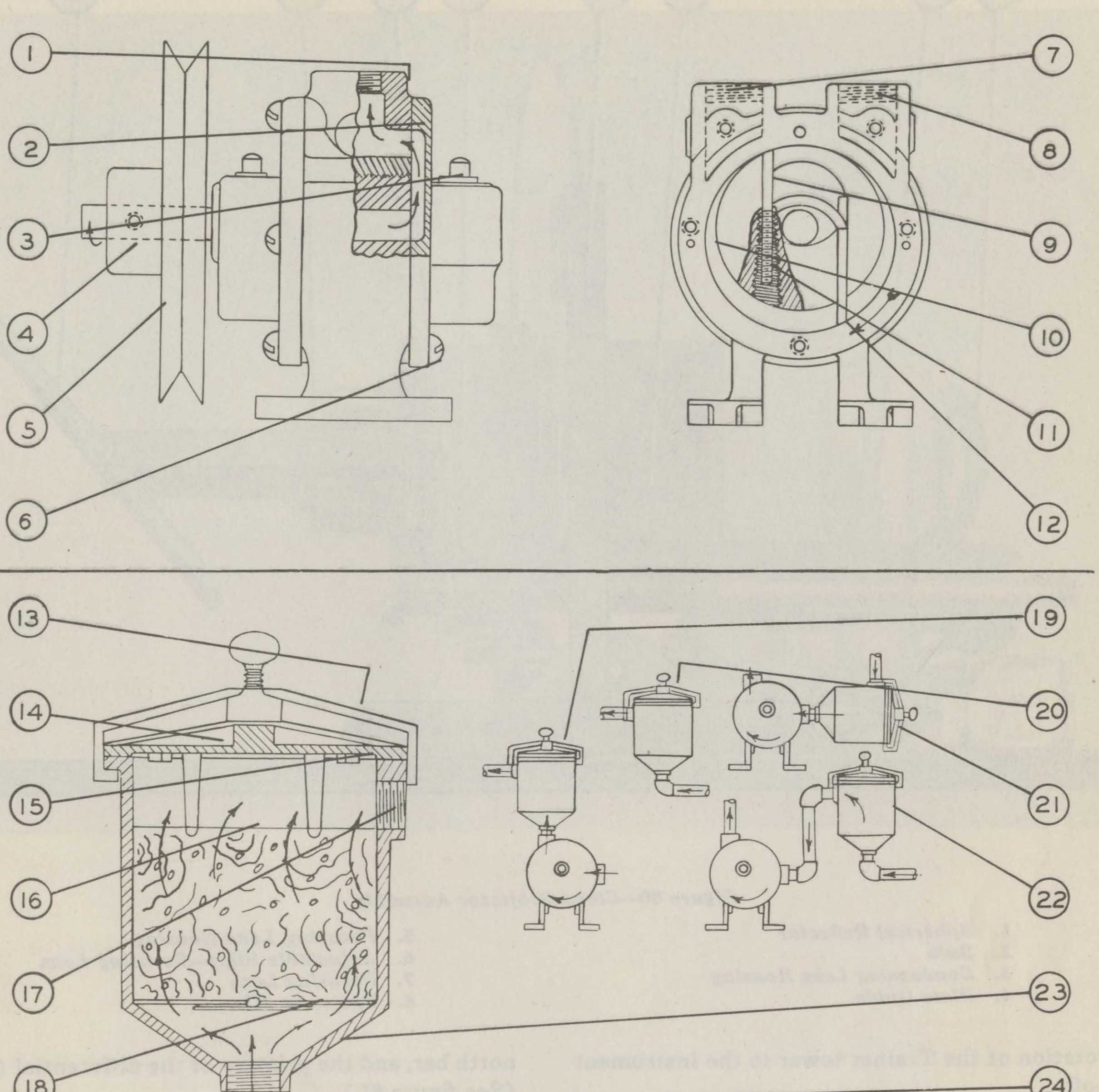

Figure 79—Altitude Pump and Filter (Schematic)

1. *Cylinder*
2. *Cylinder Head*
3. *Oil Plug*
4. *Shaft*
5. *Pulley*
6. *Cylinder Head Bolt*
7. *Outlet*
8. *Inlet*
9. *Wing (with Hook)*
10. *Piston*
11. *Stud Spring*
12. *Wing*
13. *Clamp*
14. *Cover*
15. *Gasket*
16. *Screen*
17. *Outlet*
18. *Screen*
19. *Attached to Outlet of Pump for Blowing*
20. *On Pipe Line for Blowing*
21. *On Inlet of Pump for Suction*
22. *On Pipe Line for Suction*
23. *Oil Tank*
24. *Inlet*

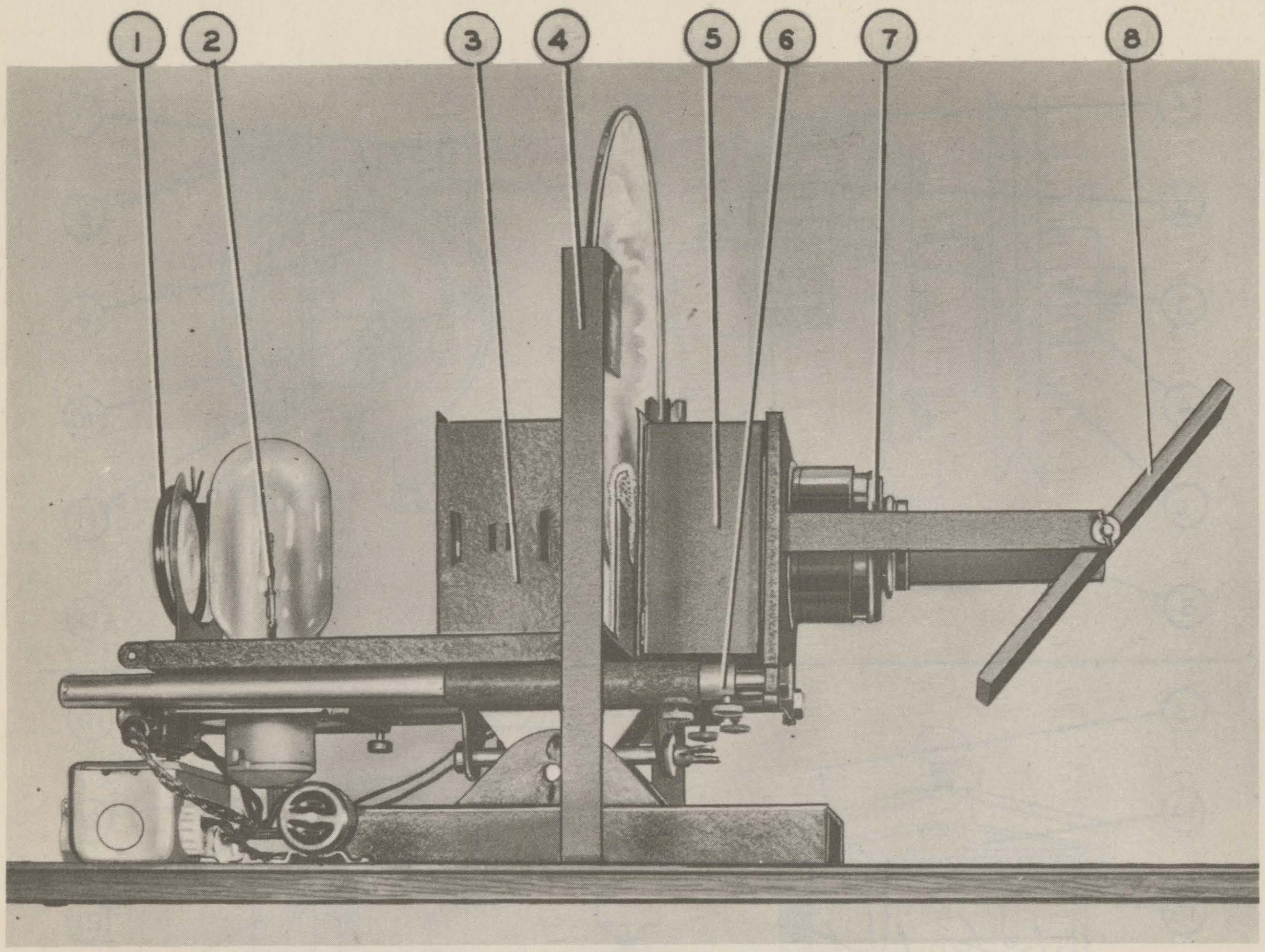

Figure 80—Cloud Projector Assembly

1. *Spherical Reflector*
2. *Bulb*
3. *Condensing Lens Housing*
4. *Plate Guide*
5. *Focusing Lens Housing*
6. *Adjustable Slide—Focusing Lens*
7. *Focusing Lens*
8. *Projector Mirror*

the rotation of the Trainer tower to the instrument take-off.

(9) INSTRUMENT TAKE-OFF.

(*a*) The instrument take-off, mounted on the top rim of the Trainer main bearing housing, is a terminal for two drives:

1. The Trainer heading drive from the large gear (A) located in the main bearing housing.

2. The drive from the azimuth loop motor located on the bottom of the instrument take-off housing and controlled by the radio receiver.

(*b*) The units driven from the instrument take-off are the wind drift mechanism, the artificial north bar, and the primary of the differential (CA). (*See figure* 81.)

(*c*) The assembly consists of five spur gears (D), (E), (F), (G), and (H), a differential (CA), an anti-backlash gear (J), a spur gear (C), pinion gears (K) and (L), the azimuth loop drive tele-torque, a 400-cycle loop drive motor, the radio compass transmitter magnesyn, and the housing. The input drive from gear (A) and pinion (B), for Trainer heading, is carried by gears (D), (E), (F), (G), and (H), and the input drive from the loop drive motor is carried by gears (C) and (J), through the differential (CA).

(*d*) The wind drift mechanism receives heading through gears (A), (B), and (E), the latter be-

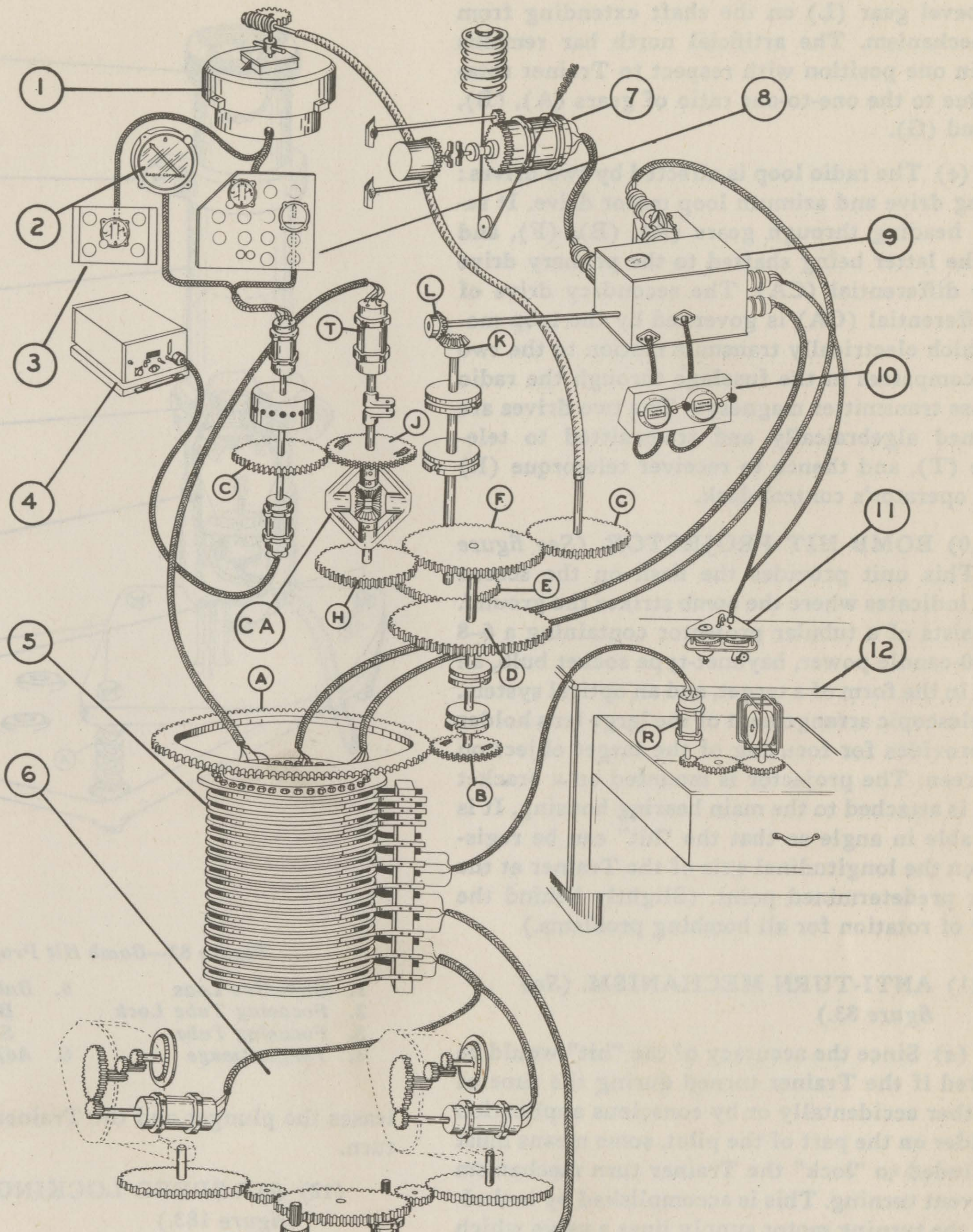

Figure 81—Instrument Drive Assembly

1. *Repeater Compass Transmitter*
2. *Navigator's Radio Compass*
3. *Navigator's Panel*
4. *SCR-269-A Receiver*
5. *Collector Rings*
6. *Projection Plate Drive Assembly*
7. *Air-Speed Control Unit*
8. *Pilot's Panel*
9. *Wind Drift Assembly*
10. *Wind Speed and Direction Control*
11. *Recorder*
12. *Desk*

ing shafted to bevel gear (K) which in turn meshes with bevel gear (L) on the shaft extending from the mechanism. The artificial north bar remains fixed in one position with respect to Trainer rotation, due to the one-to-one ratio of gears (A), (B), (F), and (G).

(*e*) The radio loop is affected by two drives: heading drive and azimuth loop motor drive. It receives heading through gears (A), (B), (F), and (H), the latter being shafted to the primary drive of the differential (CA). The secondary drive of the differential (CA) is governed by the loop motor, which electrically transmits motion to the two radio compasses in the fuselage through the radio compass transmitter magnesyn. The two drives are combined algebraically and transmitted to teletorque (T), and thence to receiver teletorque (R) in the operator's control desk.

(10) BOMB HIT PROJECTOR. (*See figure* 82.)—This unit provides the flash on the screen which indicates where the bomb strikes the ground. It consists of a tubular projector containing a 6–8 volt, 50-candle power, bayonet-type socket bulb, an object in the form of a target, and an optical system. The telescopic arrangement of the large lens holder tube provides for focusing of the target object on the screen. The projector is mounted on a bracket which is attached to the main bearing housing. It is adjustable in angle so that the "hit" can be registered on the longitudinal axis of the Trainer at the proper predetermined point. (Slightly behind the center of rotation for all bombing problems.)

(11) ANTI-TURN MECHANISM. (*See figure* 83.)

(*a*) Since the accuracy of the "hit" would be impaired if the Trainer turned during the time of fall either accidentally or by conscious application of rudder on the part of the pilot, some means must be included to "lock" the Trainer turn mechanism to prevent turning. This is accomplished by including in the turning motor supply lines a valve which automatically shuts off all air flow to the turning motors during the desired interval.

(*b*) The anti-turn mechanism consists of a solenoid whose plunger is the anti-turn valve. Upon closing the bomb release switch the solenoid becomes energized, and the valve closes the air lines to the turning motors, thus preventing a turn in either direction. At the end of the time of fall, the timer opens the circuit to the solenoid, which releases the plunger and the Trainer is again free to turn.

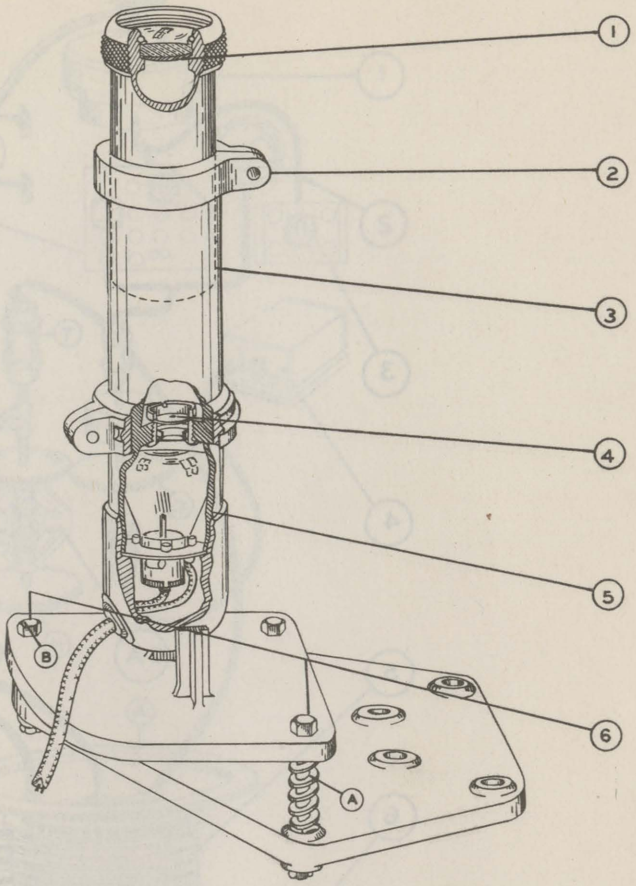

Figure 82—Bomb Hit Projector

1. *Objective Lens*
2. *Focusing Tube Lock*
3. *Focusing Tube*
4. *Target Image*
5. *Bulb (6-8 v 50 CP Bayonet-Type Socket)*
6. *Adjusting Bolts*

(12) AIR-SPEED LOCKING DEVICE. (*See figure* 183.)

(*a*) Since any change in air speed results in a proportionate change in terrain projection plate driving speed, the air speed must be kept constant during the time of fall in order that a correct "hit" may be possible. This is accomplished in the Trainer by "freezing" the air-speed input to the wind drift mechanism during the artificial time of fall.

(*b*) When the bombardier closes the bomb release switch, he causes a relay to be energized

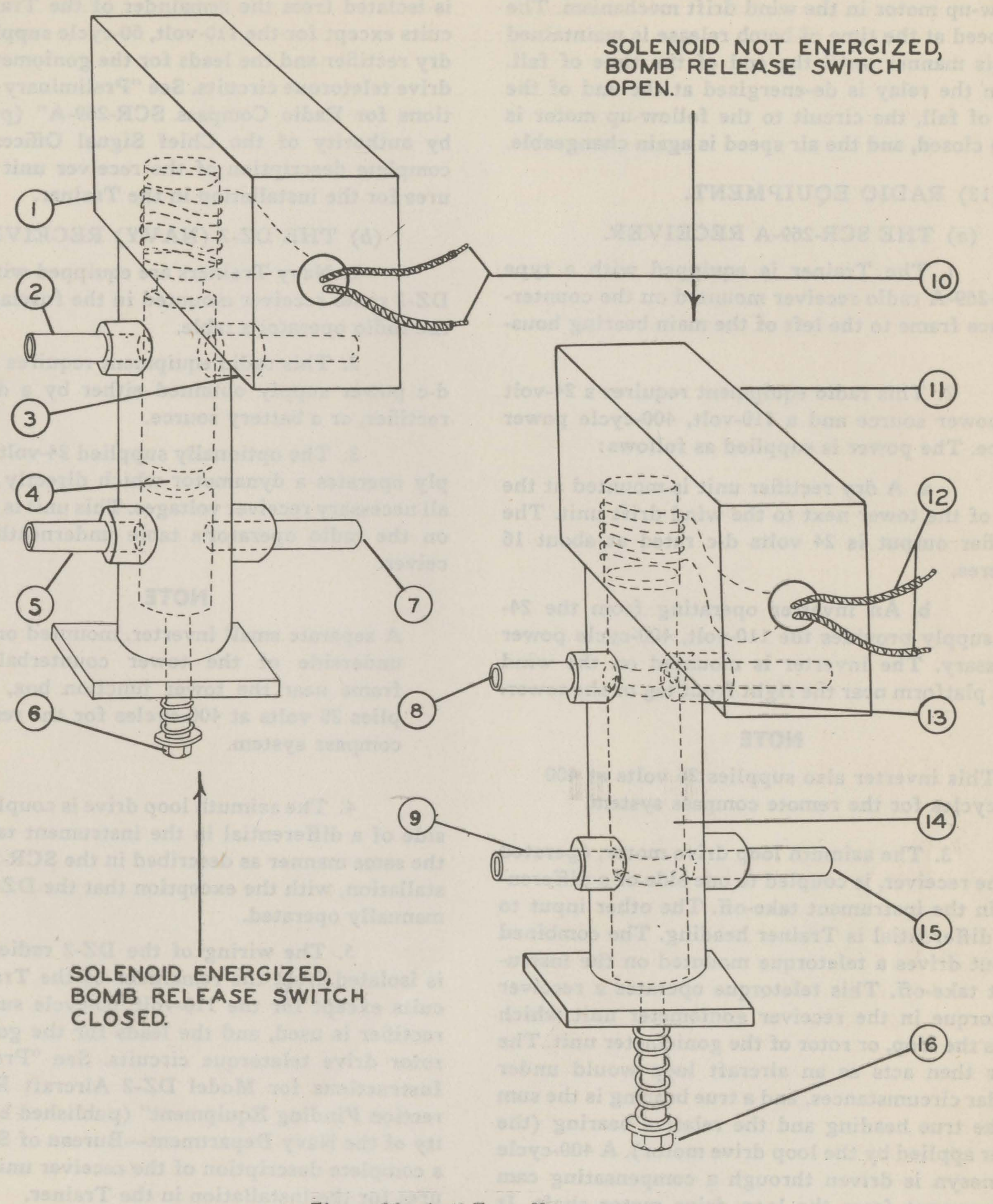

Figure 83—Anti-Turn Mecnanism

1. *Solenoid Housing*
2. *To Turning Motor*
3. *To Rudder Valve*
4. *Plunger*
5. *To Turning Motor*
6. *Spring Tension Adjustment*
7. *To Rudder Valve*
8. *To Turning Motor*
9. *To Turning Motor*
10. *Leads to Bomb Release Circuit*
11. *Solenoid Housing*
12. *Leads to Bomb Release Circuit*
13. *To Rudder Valve*
14. *Plunger*
15. *To Rudder Valve*
16. *Spring Tension Adjustment*

which in turn opens the circuit to the air-speed follow-up motor in the wind drift mechanism. The air speed at the time of bomb release is maintained in this manner until the end of the time of fall. When the relay is de-energized at the end of the time of fall, the circuit to the follow-up motor is again closed, and the air speed is again changeable.

(13) RADIO EQUIPMENT.

(*a*) THE SCR-269-A RECEIVER.

1. The Trainer is equipped with a type SCR-269-A radio receiver mounted on the counterbalance frame to the left of the main bearing housing.

2. This radio equipment requires a 24-volt d-c power source and a 110-volt, 400-cycle power source. The power is supplied as follows:

a. A dry rectifier unit is mounted at the base of the tower next to the wind drift unit. The rectifier output is 24 volts d-c rated at about 16 amperes.

b. An inverter operating from the 24-volt supply provides the 110-volt, 400-cycle power necessary. The inverter is mounted on the wind drift platform near the right front leg of the tower.

NOTE

This inverter also supplies 26 volts at 400 cycles for the remote compass system.

3. The azimuth loop drive motor, operated by the receiver, is coupled to one side of a differential in the instrument take-off. The other input to this differential is Trainer heading. The combined output drives a teletorque mounted on the instrument take-off. This teletorque operates a receiver teletorque in the receiver goniometer unit which turns the loop, or rotor of the goniometer unit. The rotor then acts as an aircraft loop would under similar circumstances, and a true bearing is the sum of the true heading and the relative bearing (the latter applied by the loop drive motor). A 400-cycle magnesyn is driven through a compensating cam arrangement from the loop drive motor shaft. It operates the receiver magnesyns in the radio compasses in the fuselage. The compensating screws and compensating cam arrangement are not used for adjustment in the Trainer installations as the errors which exist are identical for any simulated true azimuth of the station from the plane and not dependent upon Trainer heading.

4. The wiring of the SCR-269-A receiver is isolated from the remainder of the Trainer circuits except for the 110-volt, 60-cycle supply to the dry rectifier and the leads for the goniometer rotor drive teletorque circuits. See "Preliminary Instructions for Radio Compass SCR-269-A" (published by authority of the Chief Signal Officer) for a complete description of the receiver unit and figures for the installation in the Trainer.

(*b*) THE DZ-2 (NAVY) RECEIVER.

1. Navy Trainers are equipped with a type DZ-2 radio receiver mounted in the fuselage above the radio operator's table.

2. This radio equipment requires a 24-volt d-c power supply obtained either by a dry plate rectifier, or a battery source.

3. The optionally supplied 24-volt d-c supply operates a dynamotor which directly supplies all necessary receiver voltages. This unit is mounted on the radio operator's table underneath the receiver.

NOTE

A separate small inverter, mounted on the underside of the tower counterbalance frame near the tower junction box, supplies 26 volts at 400-cycles for the remote compass system.

4. The azimuth loop drive is coupled to one side of a differential in the instrument take-off in the same manner as described in the SCR-269-A installation, with the exception that the DZ-2 loop is manually operated.

5. The wiring of the DZ-2 radio receiver is isolated from the remainder of the Trainer circuits except for the 110-volt, 60-cycle supply if a rectifier is used, and the leads for the goniometer rotor drive teletorque circuits. See "Preliminary Instructions for Model DZ-2 Aircraft Radio Direction Finding Equipment" (published by authority of the Navy Department—Bureau of Ships) for a complete description of the receiver unit and figures for the installation in the Trainer.

4. BASE.

(*See figure* 85.)

a. INTRODUCTION.—The base is the steel channel section which rests on the floor of the Trainer and supports the counterbalance frame, tower, and fuselage. The base is fastened to the

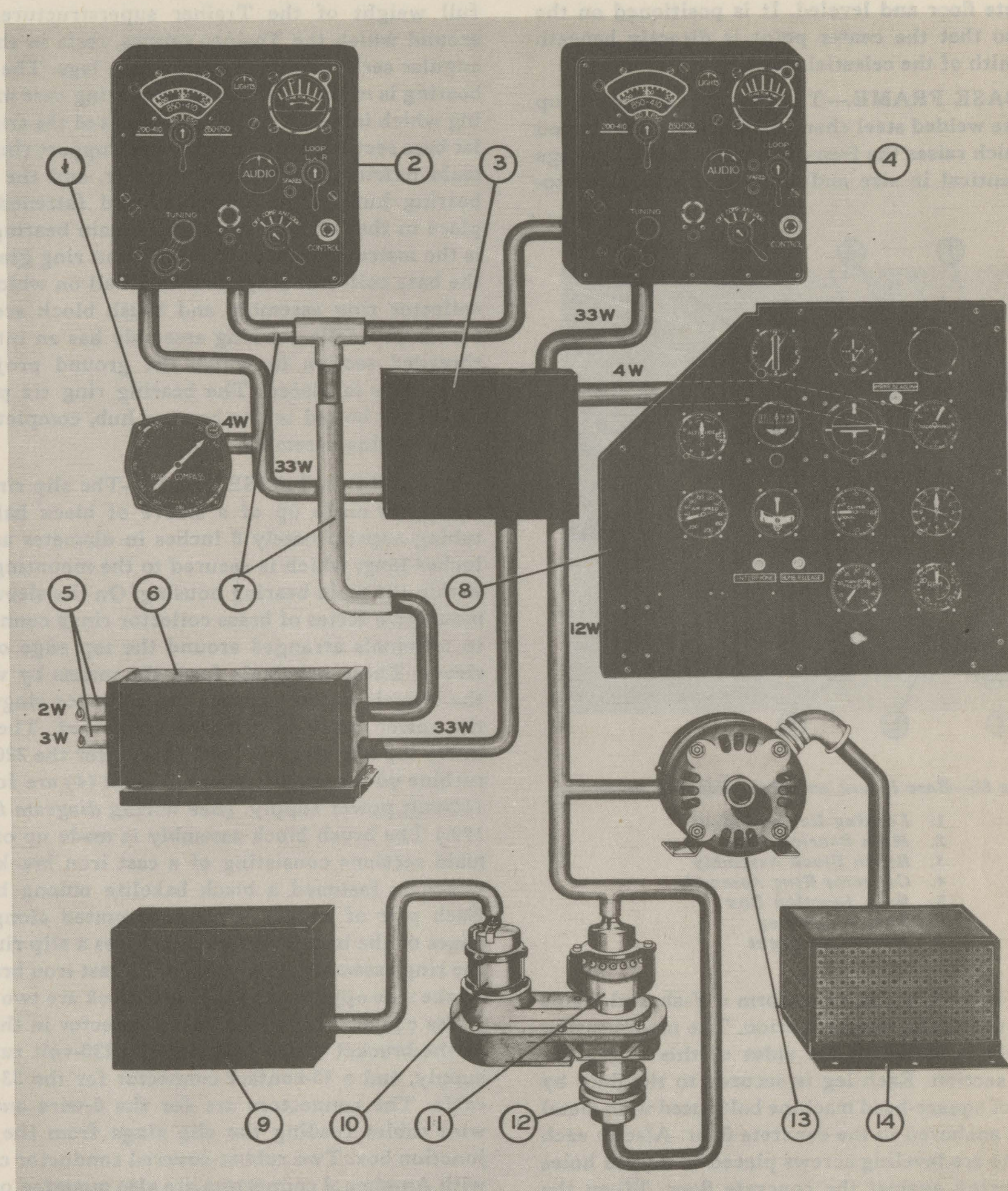

Figure 84—SCR-269-A Installation (Schematic Layout)

1. ***Navigator's Radio Compass Indicator***
2. ***Navigator's Radio Control Panel***
3. ***Automatic Radio Compass Relay Box***
4. ***Radio Operator's Control Panel***
5. ***Omni-Directional and Loop Antenna Leads***
6. ***SCR-269-A Receiver***
7. ***Flexible Tuning Shafts***
8. ***Pilot's Instrument Panel***
9. ***Tower Junction Box***
10. ***Loop Drive Teletorque***
11. ***Radio Compass Transmitter Magnesyn***
12. ***400-Cycle Loop Drive Motor***
13. ***Inverter***
14. ***Dry Plate Rectifier***

concrete floor and leveled. It is positioned on the floor so that the center point is directly beneath the zenith of the celestial dome.

b. BASE FRAME.—The base frame is made up of three welded steel channels. Each is an L-shaped leg which raises the frame above the floor. The legs are identical in size and shape and are bolted together in such a way as to form a Y-shaped frame with a triangular center section. The main bearing assembly is bolted to the sides of this triangular center section. Each leg is secured to the floor by means of square-head machine bolts used with metal shields anchored in the concrete floor. Also in each leg plate are leveling screws placed in tapped holes and bearing against the concrete floor. When the base has been accurately positioned with respect to the center of rotation of the Trainer, and the base frame has been brought to level with the leveling screws, the space between the base leg pads and the floor may be filled with a thin mixture of cement so that no space remains after leveling.

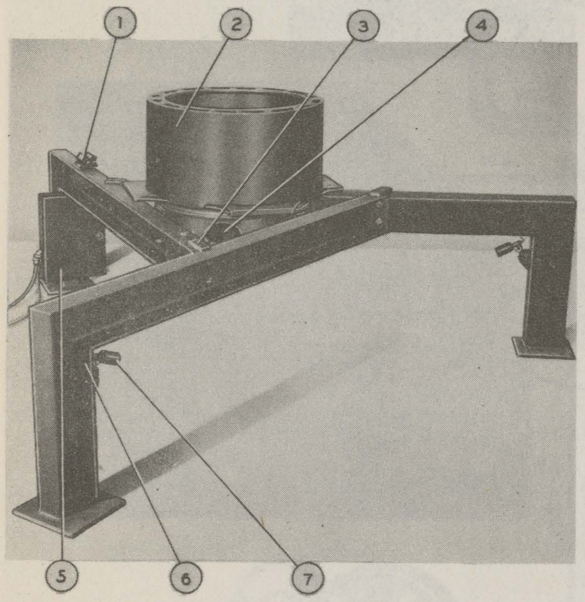

Figure 85—Base Frame and Main Bearing Assembly

1. ***Locking Device Detent***
2. ***Main Bearing Hub***
3. ***Brush Block Assembly***
4. ***Collector Ring Assembly***
5. ***Base Junction Box***
6. ***Base Frame Leg***
7. ***Moonbeam Light***

c. RADIAL BEARING. (*See figure* 86.) — A single preloaded radial bearing, which takes the full weight of the Trainer superstructure, and around which the Trainer rotates, rests in the triangular section formed by the base legs. The main bearing is made up of the inner bearing case mounting which is bolted to the three sides of the triangular base section, the bearing frame support ring, the main bearing, the bearing retainer, and the main bearing hub (to be assembled and fastened into place in that order). Within the main bearing hub is the instrument drive internally cut ring gear and the base collector ring mounting bell on which the collector ring assembly and brush block are fastened. The collector ring assembly has an internal threaded section in which the ground projector focus lens is placed. The bearing ring tie plates, which are bolted to the bearing hub, complete the main bearing assembly.

d. SLIP RING ASSEMBLY.—The slip ring assembly is made up of a sleeve of black bakelite tubing approximately 8 inches in diameter and 10 inches long, which is secured to the mounting bell within the main bearing housing. On the sleeve are mounted a series of brass collector rings connected to terminals arranged around the top edge of the sleeve. These terminals form the means by which the electric cables between the collector rings and the tower junction box are connected. The two heavy top slip rings (1) and (2) are for the 220-volt turbine power supply; rings (3) and (4) are for the 110-volt power supply. (*See wiring diagram figure* 179.) The brush block assembly is made up of two main sections consisting of a cast iron bracket to which is fastened a black bakelite oblong block. Each pair of copper brushes, mounted along the edges of the bakelite block, embraces a slip ring on the ring assembly. Mounted in the cast iron bracket on the side opposite to the brush block are two male Jones connectors; a 6-contact connector in the top of the bracket which includes the 220-volt turbine supply, and a 33-contact connector for the 33-wire cable. The connectors are for the 6-wire and 33-wire cables feeding the slip rings from the base junction box. Two rubber-covered conductor cables with Amphenol connectors are also mounted on the brush block assembly. One is for the loop drive and the other for the omni-directional antenna.

e. BASE JUNCTION BOX.—The base junction box, attached to the west (rear) leg of the base, is the distribution point for all electrical connections between the control desk in the operator's booth, and the Trainer. In the base junction box are mounted four single fuse blocks for 30-ampere car-

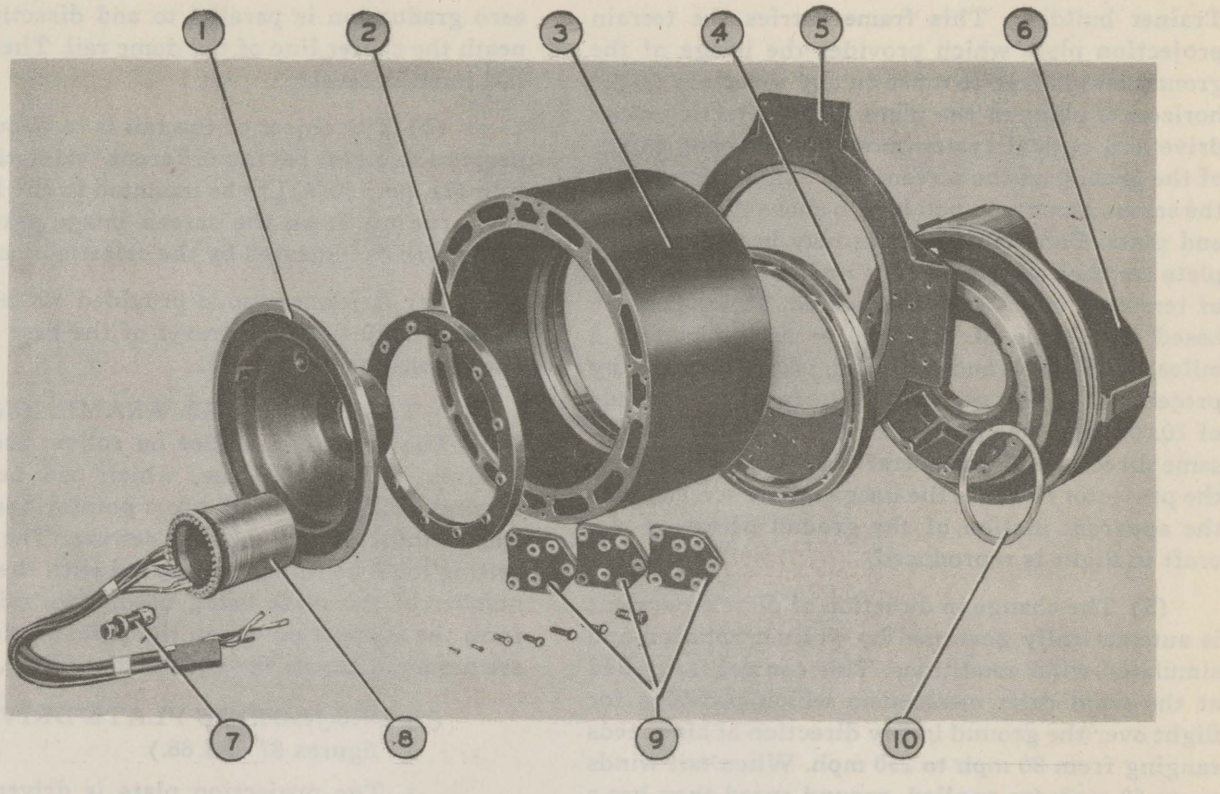

Figure 86—Main Bearing Assembly

1. *Base Collector Ring Mounting Bell*
2. *Bearing Retainer*
3. *Main Bearing Hub*
4. *Main Bearing*
5. *Bearing Frame Support Ring*
6. *Inner Bearing Case Mounting*
7. *Instrument Drive Assembly*
8. *Collector Ring Assembly*
9. *Counterbalance Frame Mounting Brackets*
10. *Instrument Drive Ring Gear*

tridge fuses, a 32-volt transformer, a 12-volt transformer and three terminal strips for wired connections.

f. TRAINER LOCKING DEVICE. (*See figure* 76.)—Bolted to the top side of the steel channel forming the rear base leg is a cast iron detent block with a U-shaped notch, so formed as to receive the roller of the tower locking device, thus producing a saddle in which the Trainer can be held in position on an east heading. Within the cast iron block is located a plunger which operates a micro-switch mounted on the counterbalance frame. The micro-switch operates a solenoid lock on the fuselage door.

g. MOONBEAM LAMPS.—Two adjustable moonbeam lamps are mounted, one on each front leg of the base, for the purpose of illuminating the terrain mechanism. The power for these lights is supplied by the 12-volt transformer in the base junction box through a 2-conductor cable that is fastened at intervals along the steel base channels to the light assemblies.

5. TERRAIN MECHANISM.

(*See figure* 87.)

a. DESCRIPTION.

(1) The terrain mechanism is primarily intended to enable the crew to fly over terrain under the same conditions as they would be in the air. To this end, the mechanism provides an image of certain terrain as seen from approximately 10,000 feet, over which flights may be made under different wind and visibility conditions.

(2) Through the glass in the floor of the navigator's compartment, a projected image of the ground may be viewed on a large screen which rotates with the Trainer. The terrain projector is mounted in a frame located on the floor of the

Trainer building. This frame carries the terrain projection plate which provides the image of the ground and is free to move in any direction in the horizontal plane of the plate. The projection plate drive and optical system provide a moving image of the ground on the screen. The Trainer tower and the screen mounted upon it turn above the projector and plate. Consecutive plates may be led into the plate carriage so that there is no limit to the length of territory which may be covered. The plates are based on a scale of 1:200,000 or approximately 3 miles to the inch and are used, when enlarged by projection on the screen, to represent an altitude of 10,000 feet. The projection plate is driven in the same direction as the aircraft (Trainer) travel and the projector reverses the image on the screen; thus the apparent motion of the ground below an aircraft in flight is reproduced.

(3) The change in direction of plate movement is automatically governed by Trainer rotation and simulated wind conditions. This control is applied at the wind drift mechanism which provides for flight over the ground in any direction at air speeds ranging from 80 mph to 250 mph. When tail winds up to 60 mph are applied, ground speed then has a value up to 310 mph.

(4) The master teletorques in the wind drift mechanism synchronize the plate and recorder travel. The recorder moves over a graticule on the operator's desk. The graticule contains the territory of the projection plate and is marked with meridians, parallels of latitude, and other reference lines. The recorder is placed on the graticule and is controlled by the wind drift mechanism so that its position on the graticule will always coincide with the position of the Trainer over the ground (projection plate). Thus, in a problem, the actual track made good, indicated by the motion of the image, is the result of the effect of the wind direction and speed, combined with the heading and air speed of the Trainer.

b. UNIT ASSEMBLIES.

(1) AZIMUTH RAIL. (*See figure* 87.)

(*a*) The azimuth rail resting on the floor of the Trainer building is equipped with hold-down bolts and leveling screws, and is graduated from zero degrees to 360 degrees. The rail is secured to the floor so that its center is on the axis of rotation of the Trainer and directly below the zenith of the rail. The center line of the azimuth rail through the zero graduation is parallel to and directly underneath the center line of the dome rail. The azimuth rail itself is level.

(*b*) The object of the rail is to allow terrain projection plates having different "azimuths" [Section III, par. 5*b*(4)] to be mounted in the frame, so that true north on the screen image agrees with true north as indicated by the celestial dome rail.

(*c*) A frame stop is provided on the bottom of the rail to limit the travel of the base frame to one revolution on the rail.

(2) TERRAIN BASE FRAME. (*See figure* 87.)—The base frame rides on rollers around the azimuth rail. The frame, which can be rotated through 360° on the rail, has a pointer fixed to one end to indicate the azimuth setting. The azimuth setting must be set to correspond with the azimuth number of the plate being used. Two rails which form the support on which the plate carriage rides are mounted across the ends of the frame.

(*a*) PROJECTION PLATE DRIVES. (*See figures* 87 *and* 88.)

1. The projection plate is driven by two (ground speed receiver) teletorque motors, spring mounted on a metal plate and fixed to the top members of the base frame so that the rubber drive wheels contact the underside of the projection plate. The driving motion to these two teletorques is supplied by the master transmitter teletorque in the wind drift mechanism. The housing of each ground speed drive is connected by a spindle and gear train to two track receiver teletorques which transmit track to the projection plate. Motion is supplied to these teletorques by two master track transmitter teletorques in the wind drift mechanism. The two receiver track teletorques are mounted on, and extend below, the base frame. Attached to either end of the frame is a depressor lever which lowers the ground speed drive housings thus disengaging the drive wheels to facilitate changing the projection plates.

2. The gear ratio between the ground speed teletorques and the plate drive wheels is sixty to one. Diameters of rubber-tired plate drive wheels are from 1.425 inches to 1.428 inches. By using the proper take-off wheel on the master teletorque in the wind drift and the above gear ratios and drive wheel diameters, the desired rate of plate travel is obtained, and corresponds to the plate scale which is 1 : 200,000. The rubber-tired drive wheels are de-

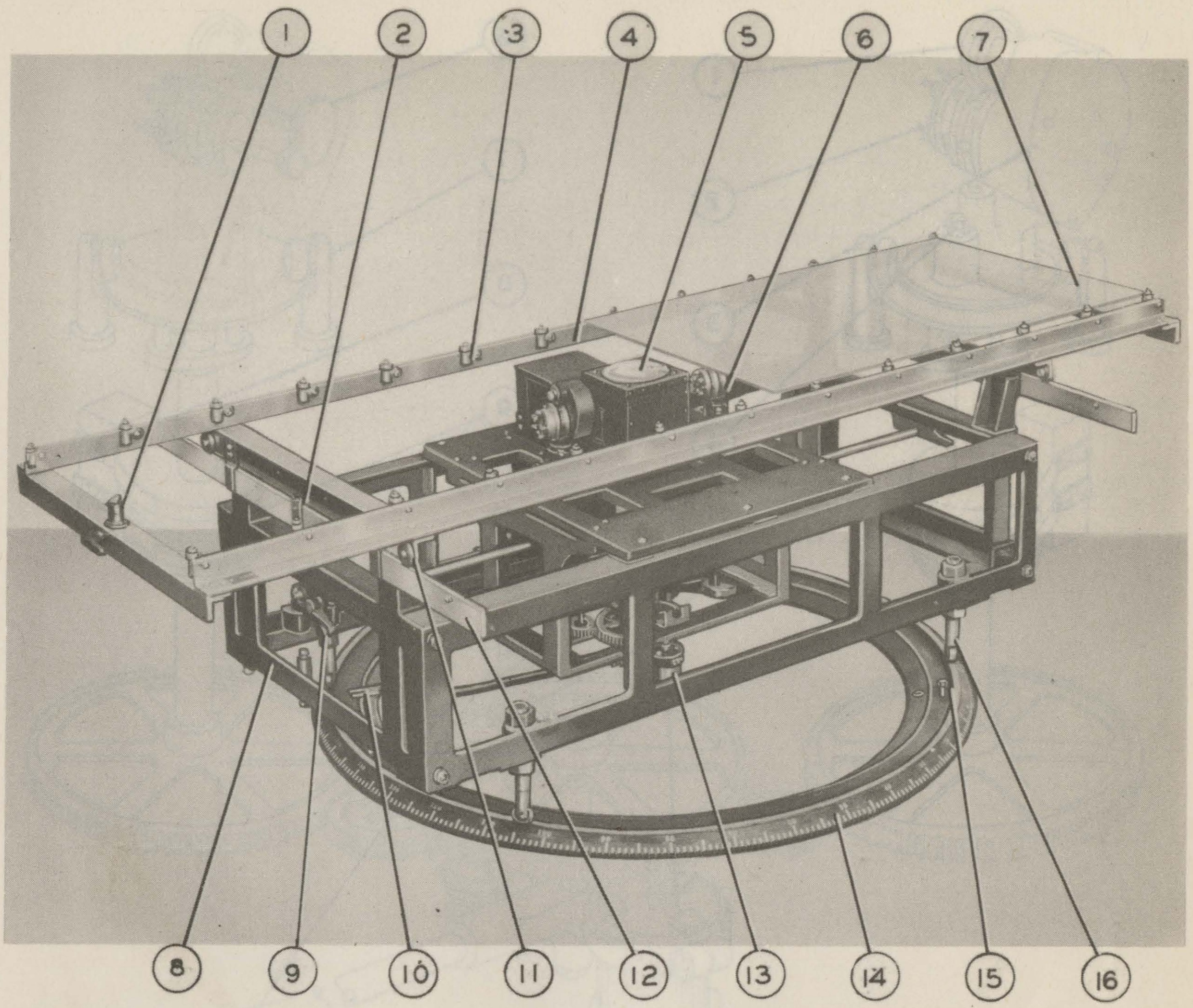

Figure 87—Terrain Mechanism

1. *Latch*
2. *End Scale Pointer*
3. *Projection Plate Rollers*
4. *Projection Plate Carriage*
5. *Terrain Projector*
6. *Projection Plate Drive*
7. *Projection Plate*
8. *Terrain Base Frame*
9. *Plate Drive Depressor Handle*
10. *Locating Arm*
11. *Plate Carriage Roller*
12. *Plate Carriage Rail*
13. *Track Teletorques*
14. *Azimuth Rail*
15. *Leveling Screws*
16. *Base Frame Roller Stud*

signed to make positive contact with under side of plate.

3. The power supply for the teletorques on the terrain mechanism is a 32-volt transformer located in the Trainer base junction box and is transmitted through two cables. A 12-conductor cable supplies 32-volt power to the ground speed plate drive teletorques, and a 4-conductor cable supplies like power to the plate direction teletorques. (*See wiring diagrams, figures* 177 *and* 178.) Both of these cables are joined to the terrain mechanism by Jones connectors.

(*b*) TERRAIN PROJECTOR. (*See figure* 90.)

1. This unit consists of a reflector, projector bulb, two vertical condensing lenses, and a 45° reflector mirror which directs the light upward at

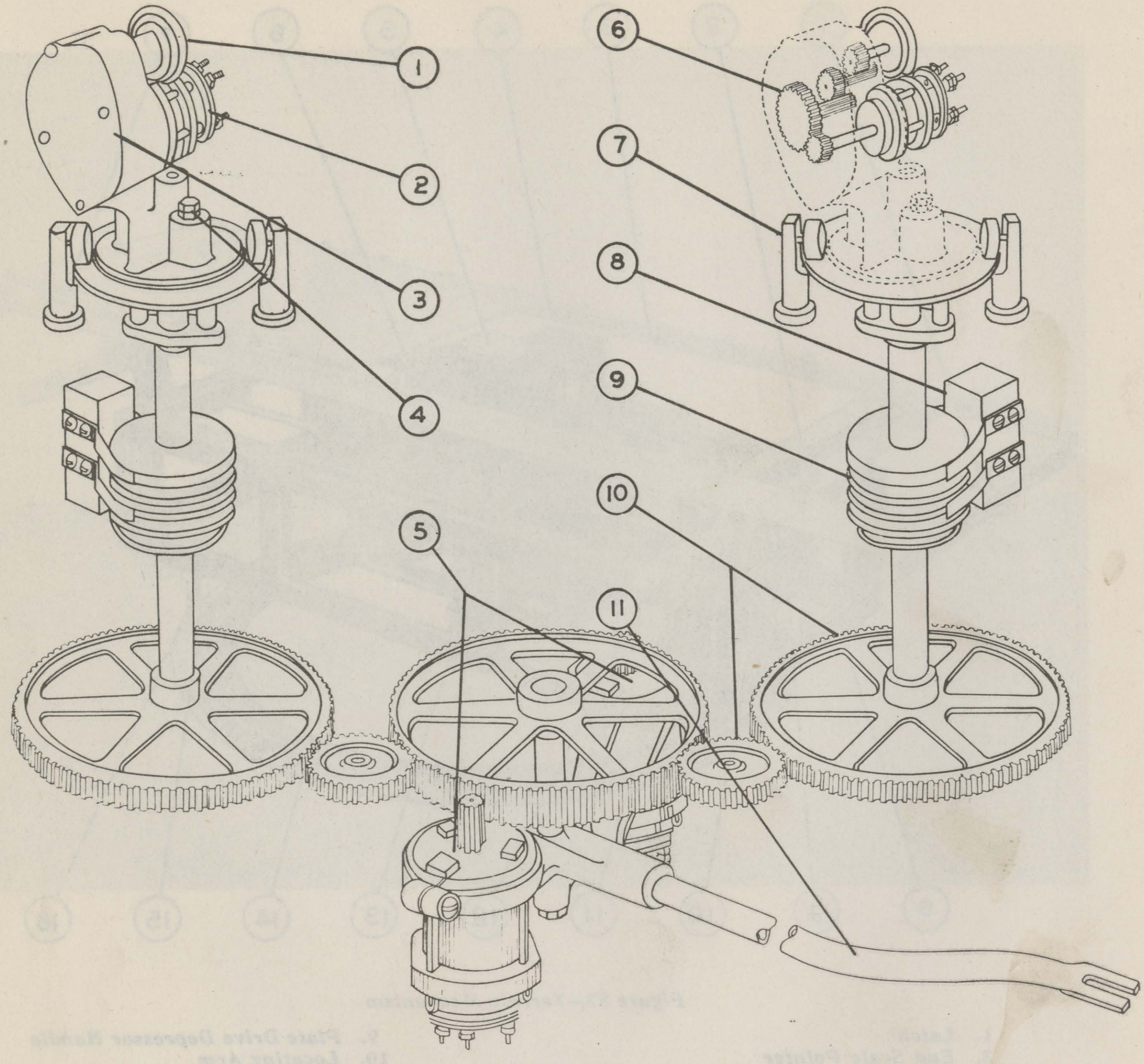

Figure 88—Projection Plate Drive

1. *Plate Roller*
2. *Plate Drive Teletorque*
3. *Teletorque Housing*
4. *Adjustment Nut*
5. *Track Teletorque*
6. *Plate Drive Gear Train*
7. *Plate Depressor*
8. *Brush Block*
9. *Collector Ring*
10. *Track Gear Train*
11. *Locating Arm*

right angles through a horizontal condensing lens. The unit is mounted on the base frame so that the horizontal condensing lens is directly under the center of rotation of the Trainer. The projector housing is provided with sliding panels which give access to the reflector, bulb and lens.

2. The light source for the terrain projector is a 500-watt, 115-volt projector type bulb.

3. A 40-watt, 115-volt, 60-cycle motor and fan are provided in order to keep the projector lamp and associated apparatus cool.

4. The voltage supply for the projector unit comes from the base junction box through the 12-conductor cable [terminals (7), (8), (9), and (10) of the Jones connector]. The lamp circuit is controlled by the master switch and the ground "on-

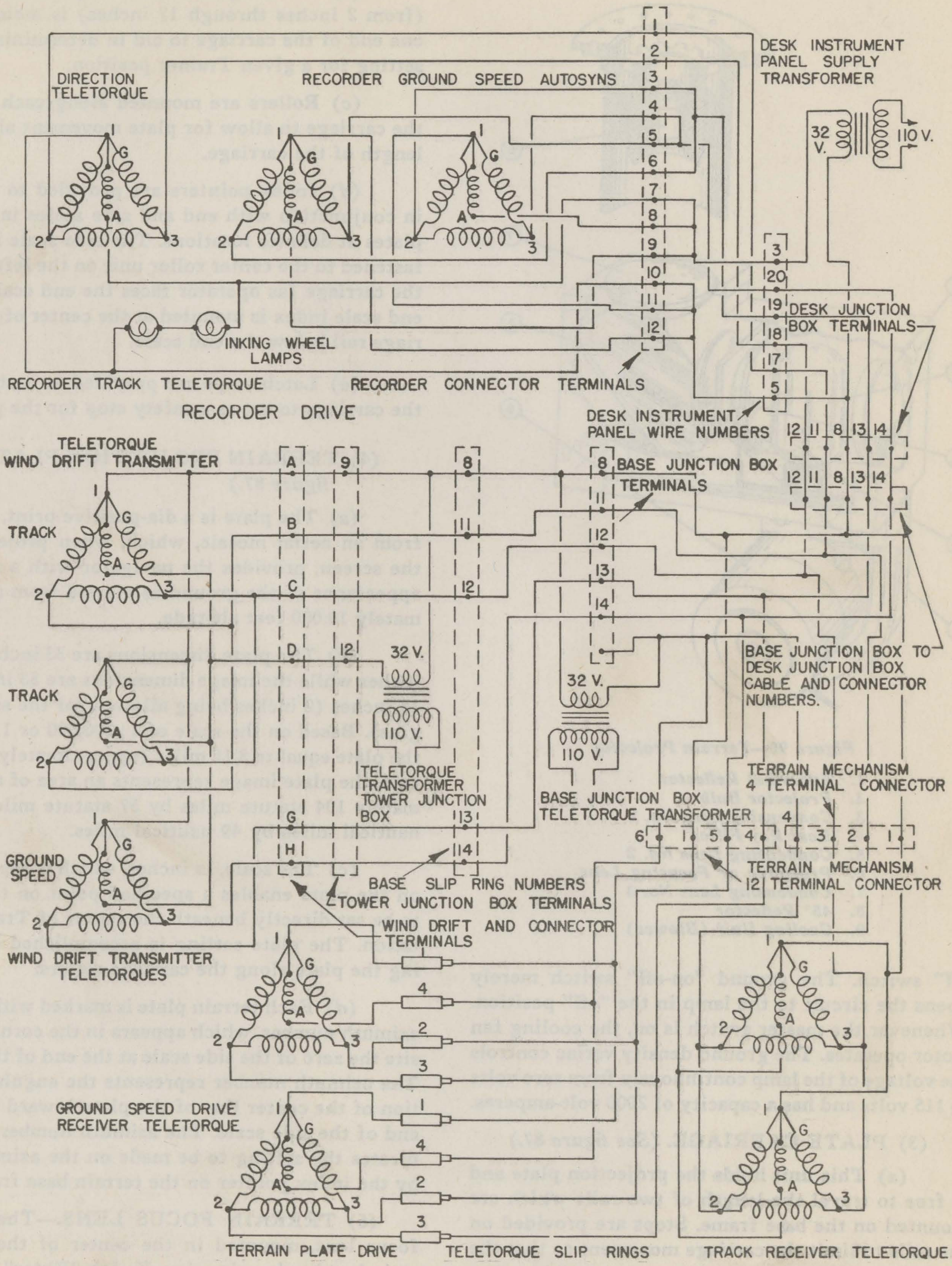

Figure 89—Wiring Diagram, Track and Ground Speed Teletorque System

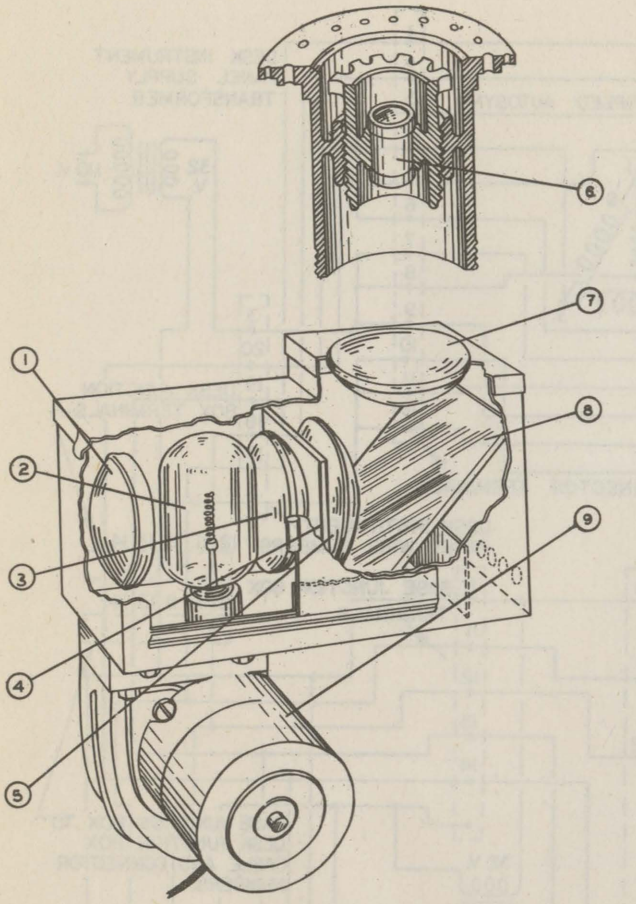

Figure 90—Terrain Projector

1. *Spherical Reflector*
2. *Projector Bulb*
3. *Condensing Lens No. 1*
4. *Heat Ray Filter*
5. *Condensing Lens No. 2*
6. *Projector or Focusing Lens*
7. *Condensing Lens No. 3*
8. *45° Reflector*
9. *Cooling Unit (Blower)*

off" switch. The ground "on-off" switch merely opens the circuit to the lamp in the "off" position. Whenever the master switch is on, the cooling fan motor operates. The ground density variac controls the voltage of the lamp continuously from zero volts to 115 volts and has a capacity of 2000 volt-amperes.

(3) PLATE CARRIAGE. (*See figure* 87.)

(*a*) This unit holds the projection plate and is free to travel the length of two rails which are mounted on the base frame. Stops are provided on the rails to limit the carriage movement so that the side edge of the plate image area never becomes visible on the screen.

(*b*) A scale graduated in eighths of an inch (from 2 inches through 17 inches) is mounted on one end of the carriage to aid in determining plate setting for a given Trainer position.

(*c*) Rollers are mounted along each side of the carriage to allow for plate movement along the length of the carriage.

(*d*) Index pointers are provided to be used in conjunction with end and side scales in setting plates at definite locations. The side scale index is fastened to the center roller unit on the left side of the carriage (as operator faces the end scale). The end scale index is mounted at the center of the carriage rail below the end scale.

(*e*) Latch stops are provided at each end of the carriage to act as a safety stop for the plate.

(4) TERRAIN PROJECTION PLATE. (*See figure* 87.)

(*a*) The plate is a dia-positive print, derived from an aerial mosaic, which, when projected on the screen, provides the navigator with a realistic appearance of the ground as viewed from approximately 10,000 feet altitude.

(*b*) The plate dimensions are 33 inches by 20 inches while the image dimensions are 33 inches by 18 inches (2 inches being allowed for the side margins). Based on the scale of 1 : 200,000 or 1 inch on the plate equal to 3.16 miles (approximately) of terrain, the plate image represents an area of approximately 104 statute miles by 57 statute miles, or 91 nautical miles by 49 nautical miles.

(*c*) The scale, in inches, which is reproduced on the plate enables a specified point on the plate to be set directly beneath the center of Trainer rotation. The plate setting is accomplished by moving the plate along the carriage rollers.

(*d*) Each terrain plate is marked with a plate azimuth number, which appears in the corner opposite the zero of the side scale at the end of the plate. The azimuth number represents the angular direction of the center line of the plate toward the zero end of the side scale. The azimuth number also indicates the setting to be made on the azimuth rail by the index pointer on the terrain base frame.

(5) TERRAIN FOCUS LENS.—The terrain focus lens, mounted in the center of the hollow main bearing housing, is a Kodak "Ektar" anastigmat lens f:3.7 focus length 105 mm. This may be

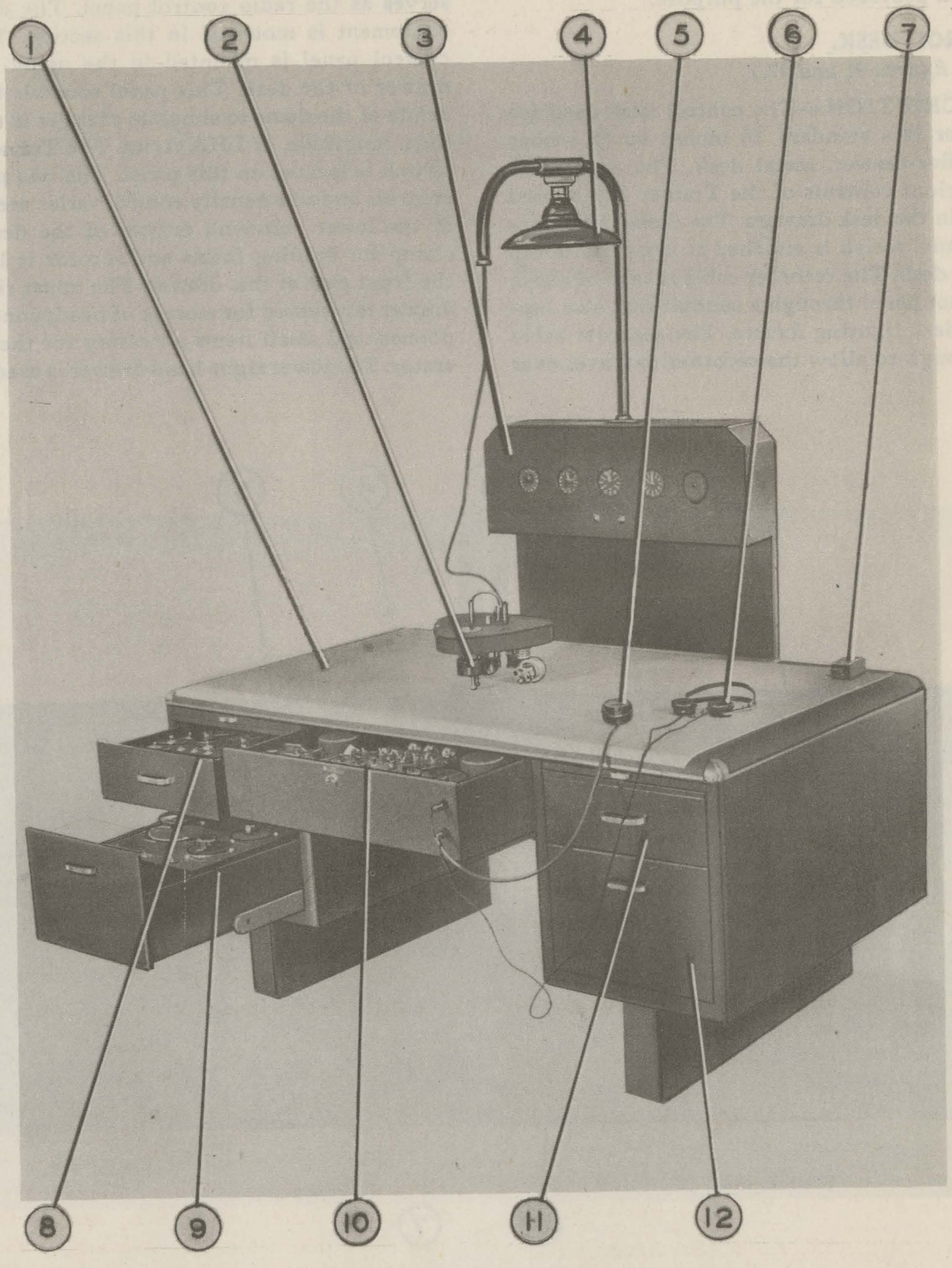

Figure 91—Control Desk Assembly

1. *Recorder Chart*
2. *Recorder*
3. *Desk Instrument Panel Assembly*
4. *Operator's Desk Lamp*
5. *Operator's Microphone*
6. *Operator's Earphones*
7. *Code Keyer*
8. *Dome Control Panel*
9. *Projection Control Panel*
10. *Radio Control Chassis*
11. *Desk Drawer*
12. *Recorder Drawer*

focused by turning the lens housing with the special wrench provided for the purpose.

6. CONTROL DESK.

(*See figures* 91 *and* 92.)

a. DESCRIPTION.—The control desk used for the Trainer is a standard 36 inches by 72 inches fiber-top, five-drawer, metal desk. The equipment for the various controls of the Trainer is mounted on panels in the desk drawers. The dome indicators are on a panel which is attached at eye level to the rear of the desk. The recorder cable is carried above the indicator panel through a conduit that also supports the desk lighting fixture. The recorder cable is long enough to allow the recorder to travel over the whole desk top. The center drawer of the desk serves as the radio control panel. The desk radio equipment is mounted in this section. The dome control panel is mounted in the upper left-hand drawer of the desk. This panel controls the movements of the dome to simulate changes in time, latitude, longitude, or LHA Aries. The Trainer master switch is located on this panel. The two projection controls and star density control variac are mounted in the lower left-hand drawer of the desk. A file clamp for holding forms and records is located in the front part of this drawer. The upper right-hand drawer is reserved for storage of headphones, microphones, and small items necessary for the desk operator. The lower right-hand drawer is used for stor-

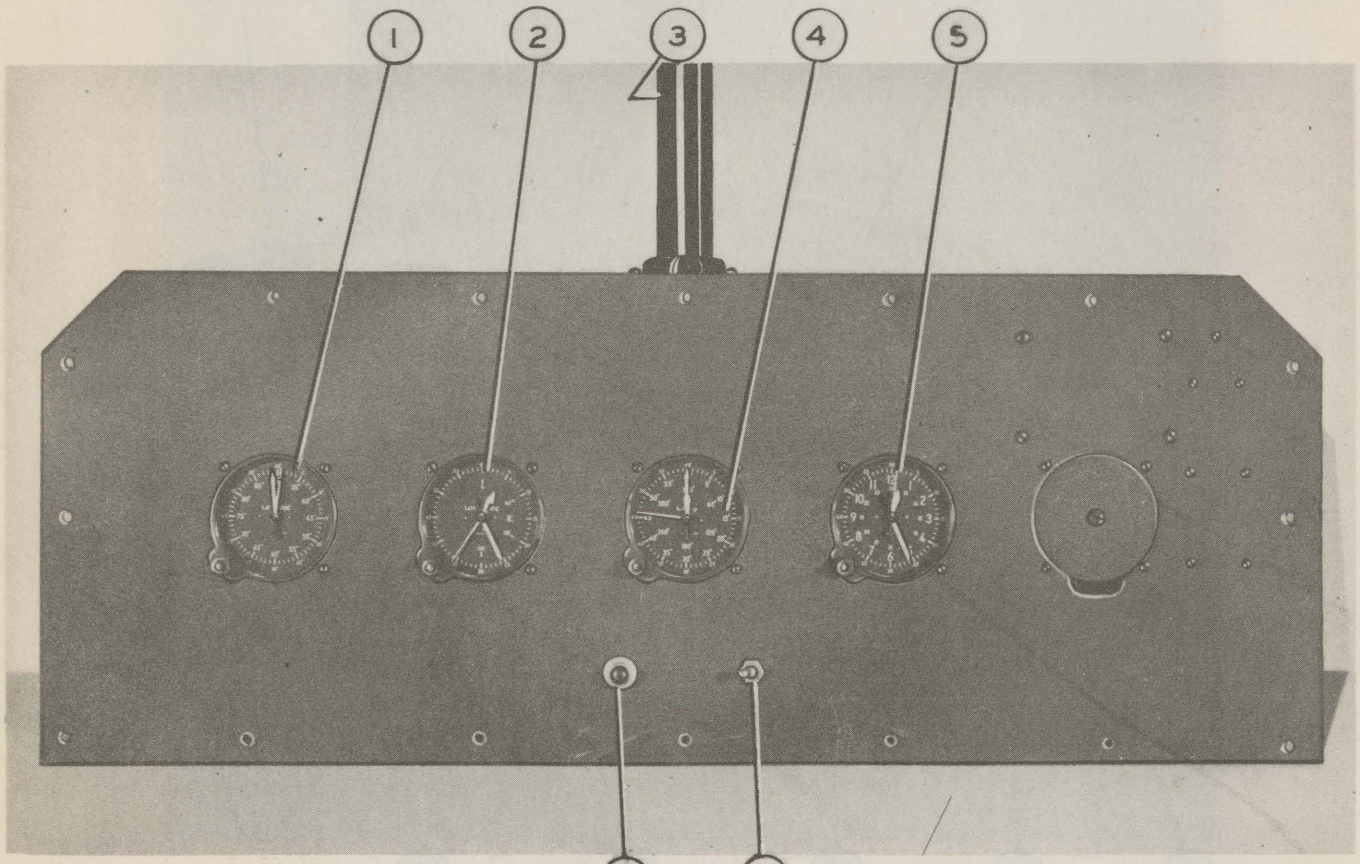

Figure 92—Desk Instrument Panel

1. *Latitude Indicator*
2. *Longitude Indicator*
3. *Goose Neck Assembly*
4. *LHA Indicator*
5. *Clock*
6. *Interphone Visual Indicator*
7. *Operator's Desk Light Switch*

age of the recorder. The control panels in the desk drawers that control dome motion, illumination or communication, are connected to the desk junction box by flexible electric cables. When more than one unit is mounted in a desk drawer, as in the radio control panel, the units are connected by cables with plug connectors.

b. PROJECTION CONTROL PANEL. (*See figure* 93.)

(1) The double size drawer in the lower left-hand corner of the desk contains the projection control panel mounted as a unit which includes the following six items: star variac, star switch, cloud variac, cloud switch, ground variac and ground switch.

(2) The projection control panel is wired from the desk junction box through a 12-wire cable. A Jones connector is used to connect the cable to the projection control panel. Each variac is controlled by a double-pole "off-on" toggle switch.

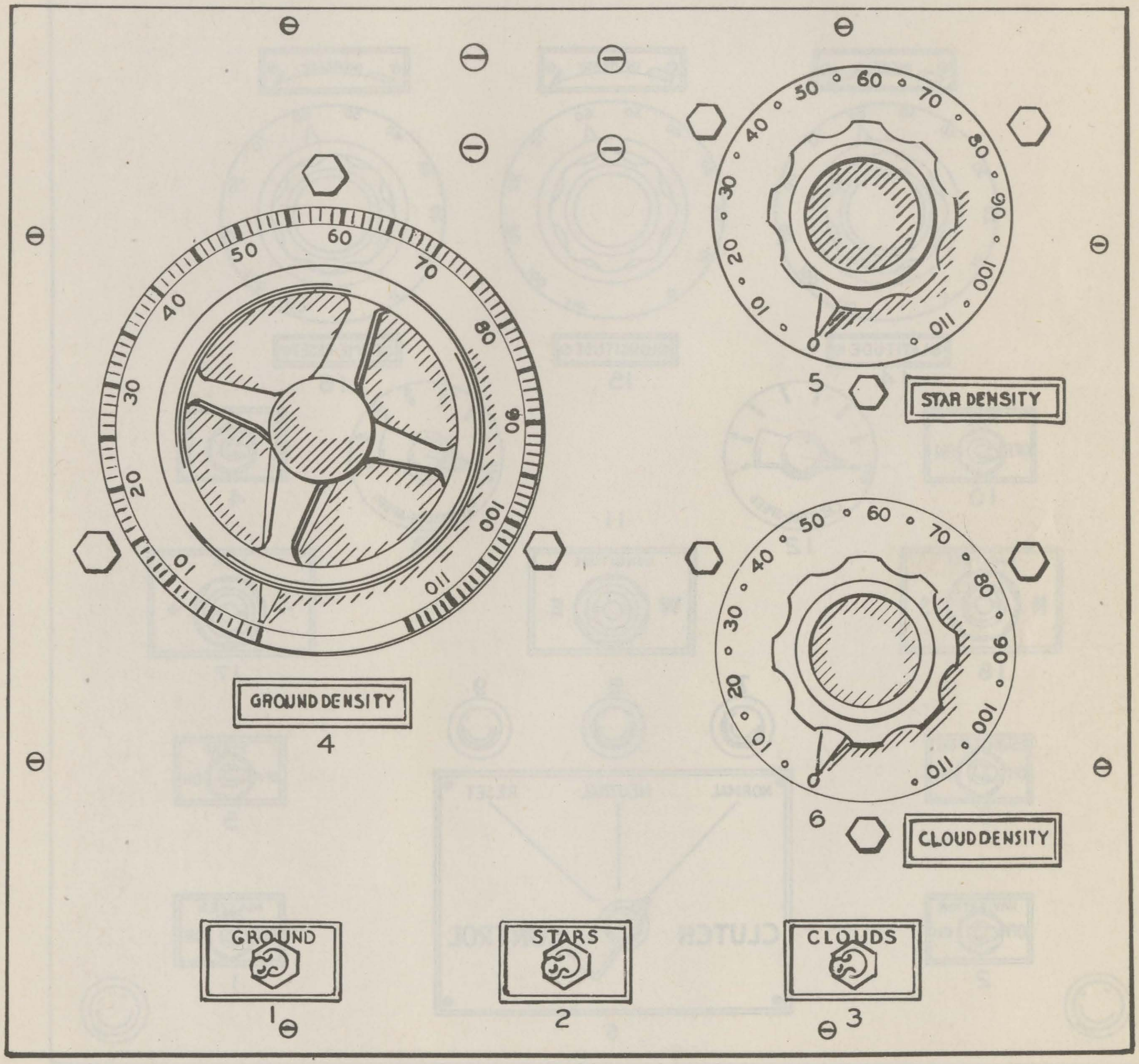

Figure 93—Projection Control Panel

(3) The star variac permits the voltage on the star transformers to be varied from zero volts to 115 volts. The capacity of the star variac is 760-volt amperes.

(4) The cloud variac is similar to the star variac.

(5) The ground variac is of similar construction to the cloud and star variacs, but is rated at 2 kva.

c. THE DOME CONTROL PANEL. (*See figure* 94.)

(1) The dome control panel in the upper left-hand drawer of the desk is the control center for the power supply of the Trainer. The following controls are on this panel:

(*a*) Master "off-on" switch.

(*b*) Navigation "off-on" switch.

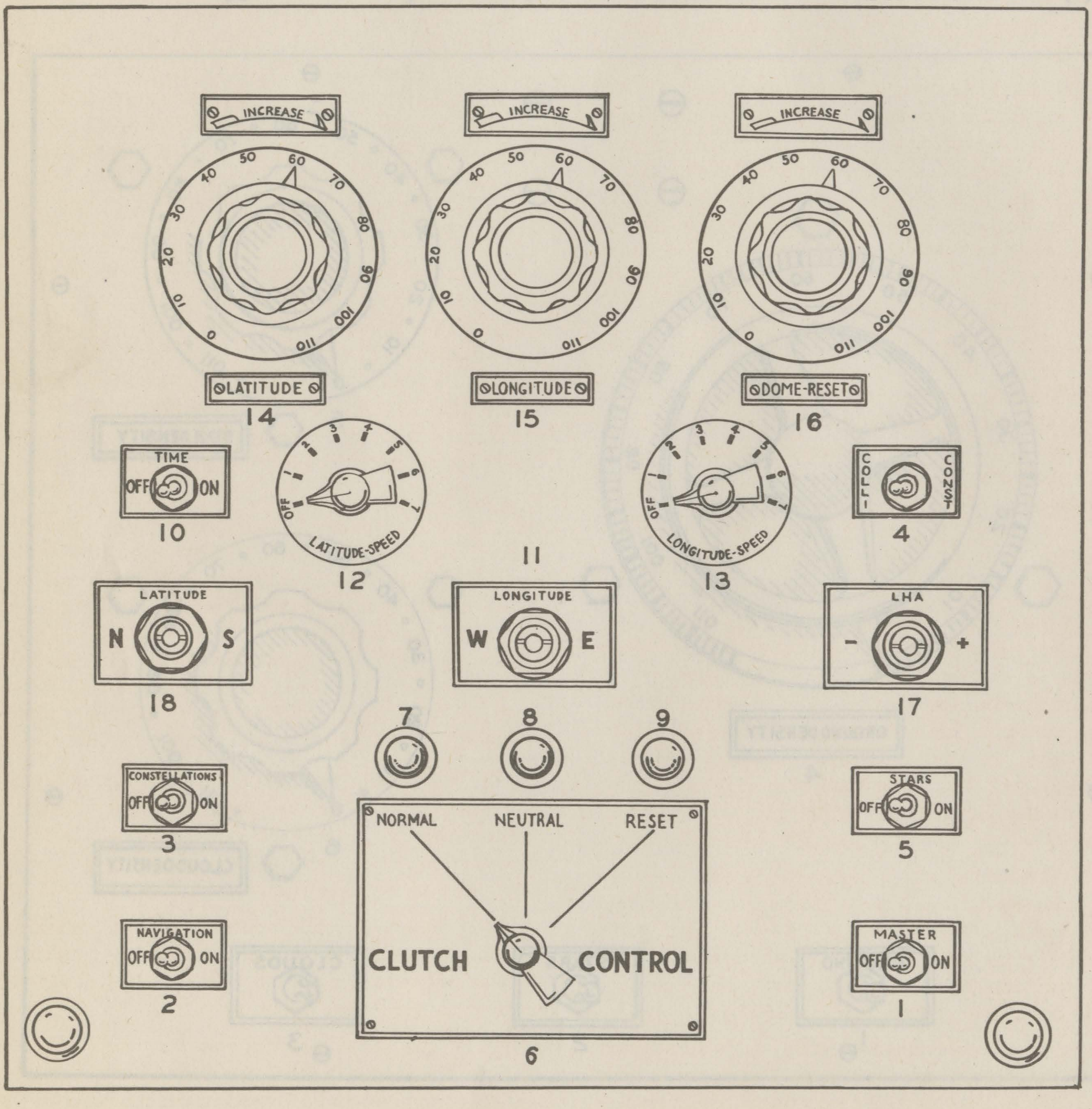

Figure 94—Dome Control Panel

(*c*) Time "off-on" switch.

(*d*) Miscellaneous stars "off-on" switch.

(*e*) Constellations "off-on" switch.

(*f*) "Collimator-Constellation" selector switch.

(*g*) Clutch Control "normal-neutral-reset selector switch" (with indicator lights).

(*h*) Dome reset "+ —" switch and variac.

(*i*) Longitude "E-W" switch, speed control, and variac.

(*j*) Latitude "N-S" switch, speed control, and variac.

(2) The dome control panel is connected with the desk junction box by two cables; a 4-wire cable carries the 110-volt, 60-cycle current to the master switch and back to the desk junction box; and a 33-wire cable. Jones plug connectors are used so the panel can be easily moved from the drawer by removing two screws near the front of the drawer and raising the panel by the knobs attached to the corners.

(3) The master switch at the front right-hand corner of the dome control panel is a two-pole "off-on" toggle switch that controls the power supply for all electrical units in the Trainer (except the desk light). The master switch is connected to the 110-volt a-c line at posts (1) and (2) to the desk junction box. The other side of the switch is connected to posts (3) and (4) of the desk junction box along with the navigation switch, the clutch control, and the dome reset variac.

(4) The navigation switch at the front left-hand corner of the dome control panel is connected directly to the time switch and the latitude and longitude variacs (controlling the latitude and longitude motors). It is also connected through cables to the desk junction box, base junction box, and tower junction box through which it is connected to the mechanism controlling the plate drive motor, air-speed follow-up motor, and anti-backlash motor.

(5) The time switch is wired in series with the navigation switch to control the time motor on the dome gear box. The circuit to the time motor leads from the time switch to desk junction box post (43), the dome cable, the time motor and post (2) on the dome gear box binding post strip.

(6) The miscellaneous stars "off-on" switch controls all stars from the third through the fourth magnitude in the dome. The circuit leads from the star variac (variable tap) to desk junction box post (6), the dome control panel cable back through the dome control panel cable to desk junction box (42), through the dome gear box, to slip ring No. 6 to the miscellaneous star transformers.

(7) The constellation switch controls all stars from zero magnitude through the 2nd magnitude. This circuit is similar to the miscellaneous star circuit. The one major difference in this circuit is the use of a relay to select the collimator recognition lamps or collimators.

(8) The "collimator-constellation" selector switch is placed in series in the circuit from the constellation switch to the constellation transformer. With this switch on the "constellation" side, all the constellation stars and the collimators are lighted; when the switch is on the "collimator" side only the collimators are lighted. The constellation switch must be in the "on" position to energize this circuit.

(9) The clutch control is a 3-position selector switch that completes the circuit to the clutch motor. Three micro-switches, mounted on the reset drive gear box mounted on the east side of the dome gear box, are operated by cams on the clutch operating shaft to break the circuit when the clutch is in the desired position. Indicator lamps on the dome control panel show the clutch position.

(10) The dome reset "+ —" switch is a double-pole, double-throw, center-locking toggle switch. When this switch is in the "+" position, the dome reset motor operates to increase the LHA Aries indication. When the switch is in the "—" position the reset motor operates to decrease the LHA Aries indication. It is impossible to throw this switch from "+" to "—" in one movement because of the center-locking feature. The switch is "off" when in the center position.

(11) The longitude switch, when placed in the "E" position, rotates the dome to simulate travel towards the east. When the switch position is "W" the dome rotates to simulate travel toward the west. The center position of the switch is "off."

(12) The longitude speed switch is an eight-position selector switch that controls the current applied to the longitude relay by selecting cam contacts of varying time duration.

(13) The reset longitude and latitude variacs used in the dome control panel are both rated at 170-volt amperes, and are used in the motor circuits indicated by the name given to the variac.

WARNING

Never set motor control variacs below 60 volts.

(14) The latitude switch and latitude speed control operate in the same manner as the longitude controls.

(15) In order to provide a wider range of average dome drive motor speeds than is available from the variac control, the latitude and longitude drive motors are supplied with a voltage that may be interrupted intermittently. The average motor speed may thus be controlled by varying the percentage of time during which the circuit to the motor is closed as follows:

(*a*) The device employed to give this control is called the intermittent speed control, and it consists of a motor driving four cams which operate two sets of contact points each. By using combinations of the cams, and with the proper switching control there are seven available "percentage of open circuit" times. The above mentioned contact points do not open and close the circuits to the latitude and longitude motors themselves, but they operate the "latitude" and "longitude" relays which in turn open and close their respective motor circuits. This prevents excessive current through the contact points as they only carry the required amount of current for the proper operation of the relays. The relatively heavier contact points of the relays do the actual work and interrupt the motor circuits.

(*b*) No. 1 cam on the first shaft makes contact ten times for every complete revolution of the shaft. Nos. 2, 3 and 4, on a second shaft driven by a ratchet with 14 teeth make contact at different intervals. For every revolution of the first shaft the ratchet is rotated one tooth. Thus, the second shaft makes one revolution for every 14 revolutions of the first shaft. No. 2 cam makes contact for 1/14 of a revolution, No. 3 for each 3/14 of a revolution and No. 4 for each 8/14 of a revolution of the second shaft. The following table gives the percentage of a given time unit during which the current is applied to the longitude motor:

Switch Position	*Percentage*	*Switch Position*	*Percentage*
Off	0.%	4	10.0%
1	0.745%	5	21.4%
2	2.14%	6	57.0%
3	5.72%	7	100.0%

d. RADIO. (*See figure* 95.)

(1) EQUIPMENT.—The center drawer of the desk contains all the radio equipment necessary to produce the radio effects used in the Trainer. The control panel occupies the center section of the drawer with the power supply and left transmitter on the left side, and the pickup goniometer and right transmitter on the right side. The necessary connections from one unit to another, and from the desk junction box to the radio controls, are made by cables fitted with Jones plug connectors. The cable plugs and receptacles on the units are color coded to aid in connecting the parts together correctly. The radio section of the Trainer is comprised of five units:

(*a*) Two transmitter units
(*b*) The control chassis
(*c*) The power supply
(*d*) The pick-up goniometer unit

(2) ASSEMBLIES.

(*a*) TRANSMITTERS. (*See figures* 96 *and* 97.)—The two transmitters each contain a radio frequency oscillator, a transmitter goniometer unit, an omni-directional antenna and controls, such as frequency control from 200 kc to 400 kc, modulation selector switch, transmitter volume, station azimuth control, and trimming adjustments for the frequency control, and for the control tower signal on 278 kc.

1. TRANSMITTER UNITS.—There are two of these units whose purpose is to produce a signal similar to that emanating from a regular broadcast, range, or code transmitter with the choice of voice-on-range if the operator or instructor wishes. In addition to transmitting any one or a combination of the above signals, a directive effort is designed into one of the antenna systems in such a way that it is possible to simulate a station for radio direction finding; and, in effect, locate the station in any direction from the plane and maintain it in that relative position during the entire flight.

2. OSCILLATOR CIRCUIT. (*See wiring diagram, figure* 201.)—The transmitter consists of a "6K8" (VT1) oscillator-amplifier tube circuit with tuned plate circuit and switching arrangement enabling the operator to vary the RF output continuously from 200 kc to 400 kc, or set by using (SW1) a fixed output frequency of 278 kc. The RF oscillator can be modulated from any of the desired

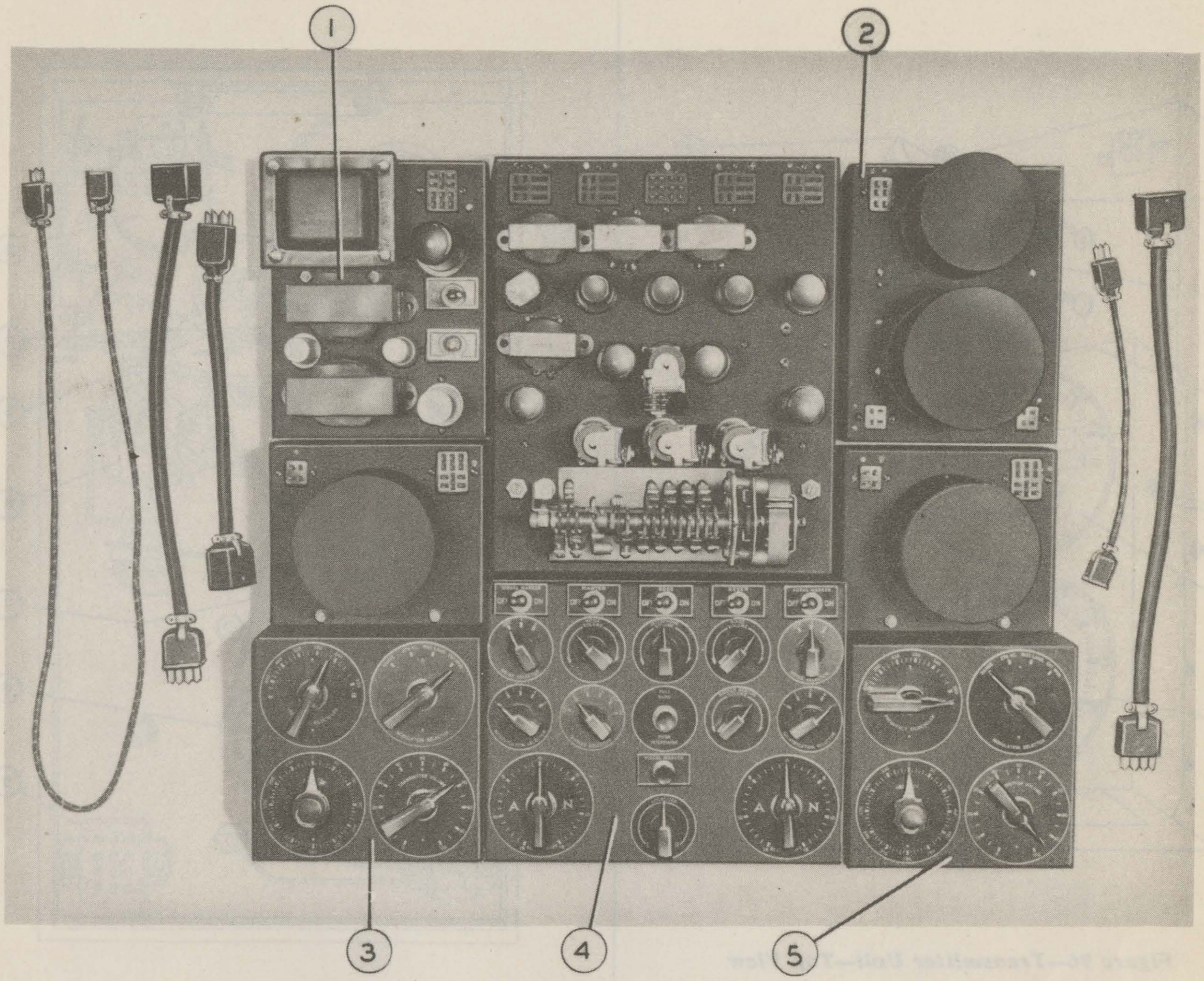

Figure 95—Radio Assembly

1. *Desk Power Supply*
2. *Pick-up Goniometer Unit*
3. *Left Transmitter*
4. *Control Assembly*
5. *Right Transmitter*

sources, voice, beam, marker signals, noise or combinations of two or more signals in order to simulate any radio normally used in radio and instrument flight. The frequency band is governed by the position of (SW1) and the product of LC of the RF transformer (T1) and the bank of condensers (C3), (C4), and (C5) for No. 1 switch position, (C6) and (C7) for No. 2 position, while No. 3 and No. 4 positions are connected the same as No. 1. Modulation takes place in the amplifier grid through the connection at the top of the tube. The volume is controlled by (R1) which is connected across the input signal to ground with the slider arm to the grid. Amount of modulation is controlled by varying the amount of resistance in the cathode bias circuit with control resistor (R2) on the same shaft as the volume control. This type of control keeps the modulation signal and radio frequency signal in the proper ratio throughout the entire range of control. Note that when the modulated input signal is increased by moving the transmitter volume control slider toward the high resistance side, the cathode bias is proportionally reduced by the lessening of resistance since the top side of (R2) is connected to ground. The output of the amplifier is fed into the RF transformer (T2) tuned by (C3), (C4) and (C5) for No. 1 position of (SW1) and (C6) and (C7) for position No. 2. Positions No. 3

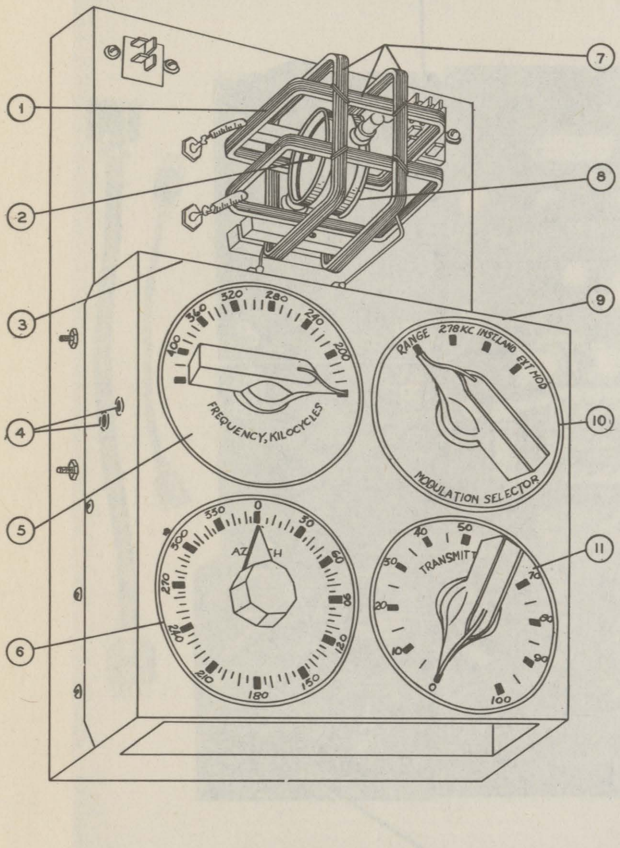

Figure 96—Transmitter Unit—Top View

1. *Transmitter Goniometer Stator Coil*
2. *Setscrew*
3. *278 kc "Trim"*
4. *Frequency Control "Trim"*
5. *Frequency Control*
6. *Azimuth Control*
7. *Transmitter Goniometer Stator Coils*
8. *Transmitter Goniometer Rotor Coil*
9. *278 kc "Trim"*
10. *Modulation Control*
11. *Volume Control*

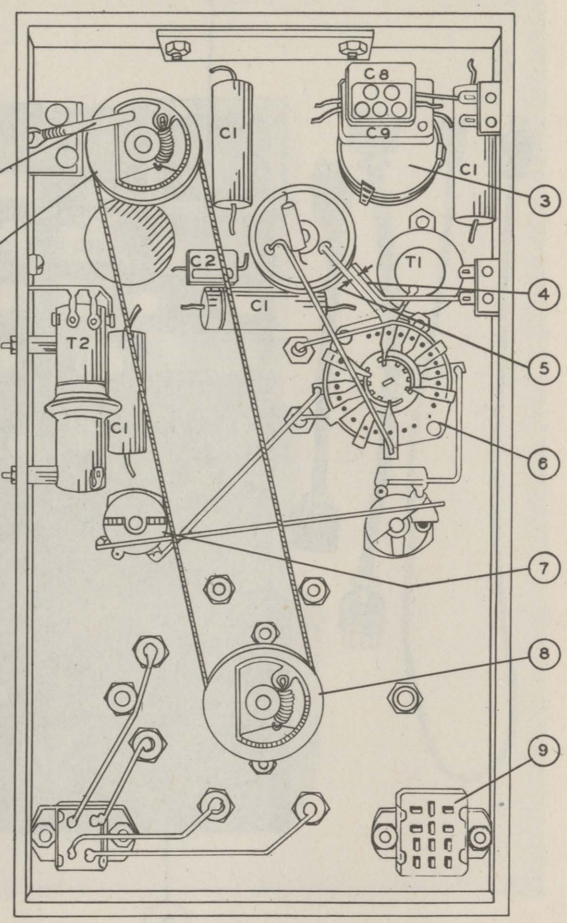

Figure 97—Transmitter Unit—Bottom View

1. *Azimuth Control Stop*
2. *Azimuth Control Pulley*
3. *Transmitter Volume*
4. *Omni-Directional Antenna*
5. *Coupling Distance*
6. *Modulation Selector Switch*
7. *278 kc Trimming Condensor*
8. *Transmitter Goniometer Rotor Drive Pulley*
9. *Jones Connector*

and 4 are connected to No. 1. The secondary of (T2) is connected into the windings of the goniometer which is explained in the following paragraph. Modulation is fed into the circuit through the No. 1 and No. 3 position of the one "wafer" of (SW1), and No. 2 of the other "wafer" which are connected directly to the connector No. 10015 (figure 199).

3. THE TRANSMITTER GONIOMETER UNITS. (*See figure* 98.)—The transmitters feed the rotors of the transmitter goniometer units. The radio frequency current in these rotors produces a field in the transmitter units. This field interlocks the stator coil and thus induces currents in these stator coils. The stator coils in turn are electrically connected to the stator coils of the pick-up goniometer unit and thus the same currents flow in the stator coils of the pick-up unit as flow in the transmitter goniometer units. Hence, the field set up by the pick-up goniometer unit stator

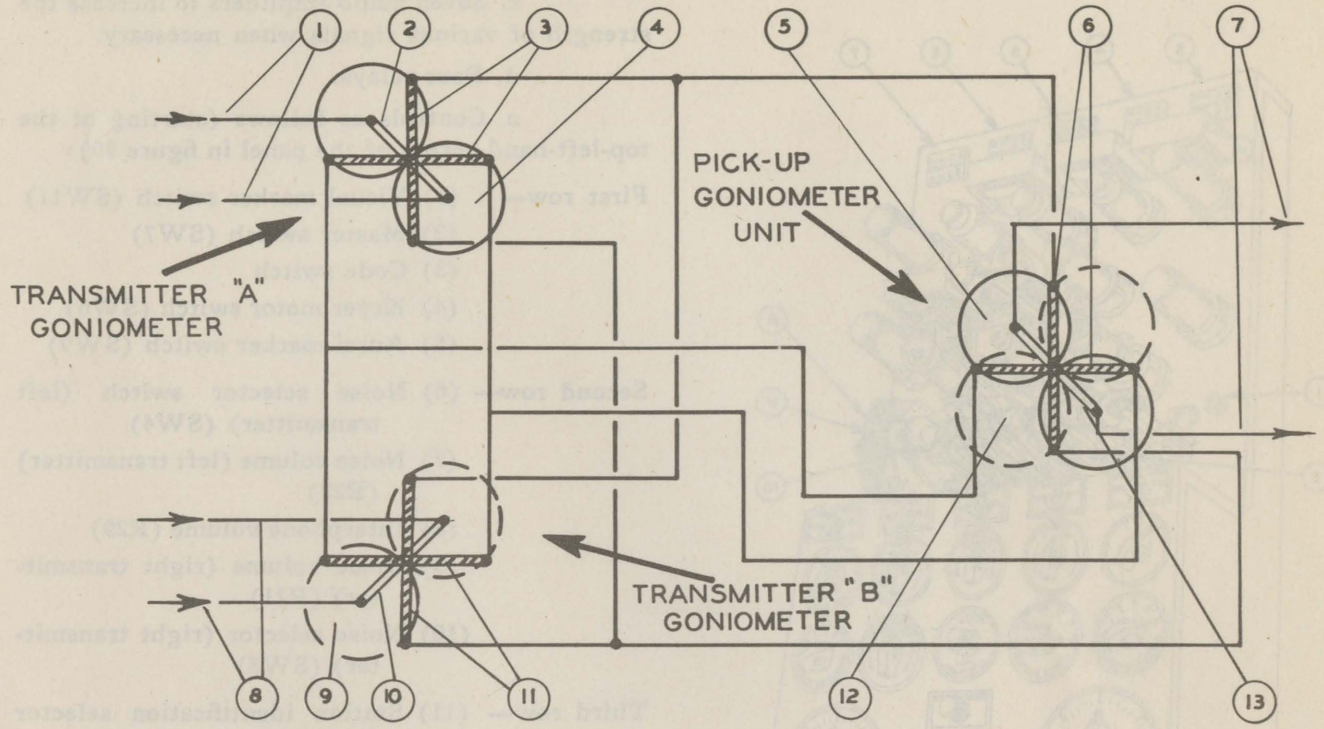

Figure 98—Goniometer System of the CNT Radio

1. ***Signal from Transmitter "A"***
2. ***Transmitter "A" Rotor Coil***
3. ***Transmitter "A" Stator Coils***
4. ***Rotor Field Pattern***
5. ***Field from Transmitter "A"***
6. ***Pick-up Goniometer Stator Coils***
7. ***Leads to Receiver Loop***
8. ***Signal from Transmitter "B"***
9. ***Rotor Field Pattern***
10. ***Transmitter "B" Rotor Coil***
11. ***Transmitter "B" Stator Coil***
12. ***Field from Transmitter "B"***
13. ***Pick-up Goniometer Rotor Coil***

coils is the same as the field in the transmitter goniometer unit. Since the two transmitter goniometer units feed the pick-up goniometer unit in parallel, the fields of both transmitter units exist in the pick-up goniometer unit. This causes no interference as long as the frequencies are more than 10 kc apart. The field used depends on the frequency to which the receiver is tuned and the signal strength in the loop depends on the angular relationship between the loop and the field existing in the goniometer unit. When the field is parallel to the pick-up goniometer loop, the voltage induced in the loop (loop signal strength) is at a minimum [refer to field of (B) and pick-up rotor in figure 98], and when the field is perpendicular to the loop [shown in the case of the field of (A) in figure 98] the voltage is at a maximum.

4. OMNI-DIRECTIONAL ANTENNA. (*See figure* 97.)—This antenna is a short length of wire placed adjacent to a lead in the oscillator circuit of the transmitter. The distance between the two wires is actually the only distance over which radio frequency waves are transmitted. Obviously, the oscillator strength necessary to accomplish this is very small. The capacitive coupling between the "hot" lead and the antenna serves to energize the antenna. Signal strength is adjusted by varying the distance between the lead and the antenna and thus varying the coupling.

(*b*) RADIO CONTROL CHASSIS. (*See figures* 99, 100, *and wiring diagram, figure* 199.)

1. CONTENT.—The radio control panel of the Trainer, located in the center drawer of the desk, contains the main radio assemblies and its purpose is to serve as a control center from which the desired audio signals are fed to the transmitters,

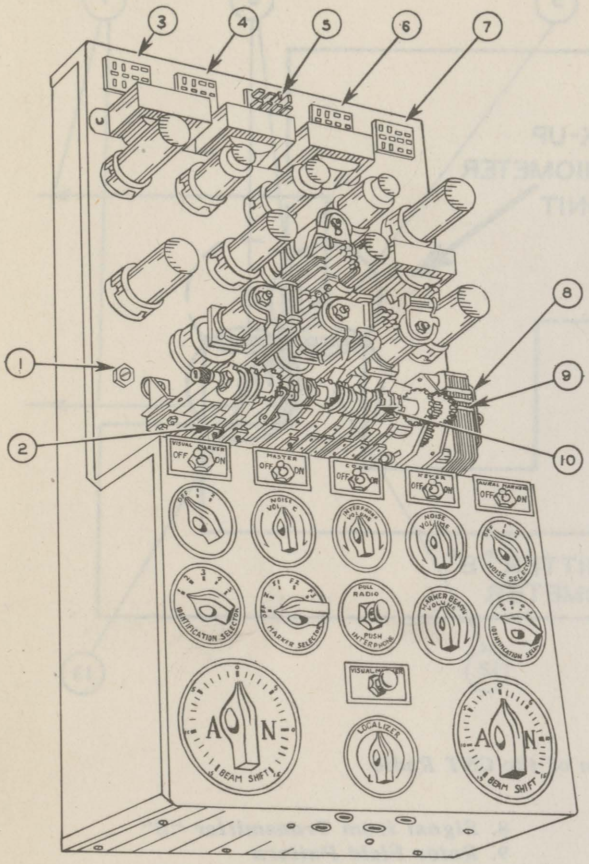

Figure 99—Radio Control Chassis—Top View

1. *Left Beam Shift Centering Control*
2. *Contact Point Adjustments*
3. *To Left Transmitter*
4. *To Desk Power Supply*
5. *Cable "A" to Desk Junction Box*
6. *Cable "B" to Desk Junction Box*
7. *To Right Transmitter*
8. *Right Beam Shift Centering Control (not shown)*
9. *Keyer Motor*
10. *Keyer Cams*

simulating at the discretion of the operator any commonly used radio signals received during flight, using any type of radio navigation such as radio "fixes," "range" stations, "marker beacon" signals or even broadcast stations. Interphone or "voice-on-beam" is also available between the desk and the fuselage through a special circuit. The control chassis contains:

a. Three audio oscillators for generating the various necessary audio signals.

b. The keyer unit to key the range and marker signals.

c. Seven audio amplifiers to increase the strength of various signals when necessary.

d. Four relays.

e. Controls as follows (starting at the top-left-hand corner of the panel in figure 99):

First row—
(1) Visual marker switch (SW11)
(2) Master switch (SW7)
(3) Code switch
(4) Keyer motor switch (SW6)
(5) Aural marker switch (SW9)

Second row—
(6) Noise selector switch (left transmitter) (SW4)
(7) Noise volume (left transmitter) (R22)
(8) Interphone volume (R29)
(9) Noise volume (right transmitter) (R21)
(10) Noise selector (right transmitter) (SW3)

Third row—
(11) Station identification selector (left transmitter) (SW1)
(12) "Z" or "FM" marker selector (SW10)
(13) "Interphone-radio (push-pull) switch (SW5)
(14) "Z" or "FM" marker beacon volume (R3)
(15) Station identification selector (right transmitter) (SW2)

Fourth row—
(16) Left transmitter A-N mixer control (R41)
(17) Visual marker (push-button) switch (SW8)
(18) Localizer "left-right" control (R43)
(19) Right transmitter A-N mixer control (R40)

2. THE 1020-CYCLE RANGE OSCILLATOR.—This circuit consists of a 6C5 (VT2) amplifier-oscillator tube and connects to (T2), (C5), (R6), and (C7) with the plate voltage which is fed through (R5) and (C6) acting as a bypass filter for any 1020-cycle signal which might tend to flow through (5), thus effecting quality and stability of the range signal. Frequency is governed by the amount of inductance, the capacity of transformer (T2), and the combination (C5) and (R6) con-

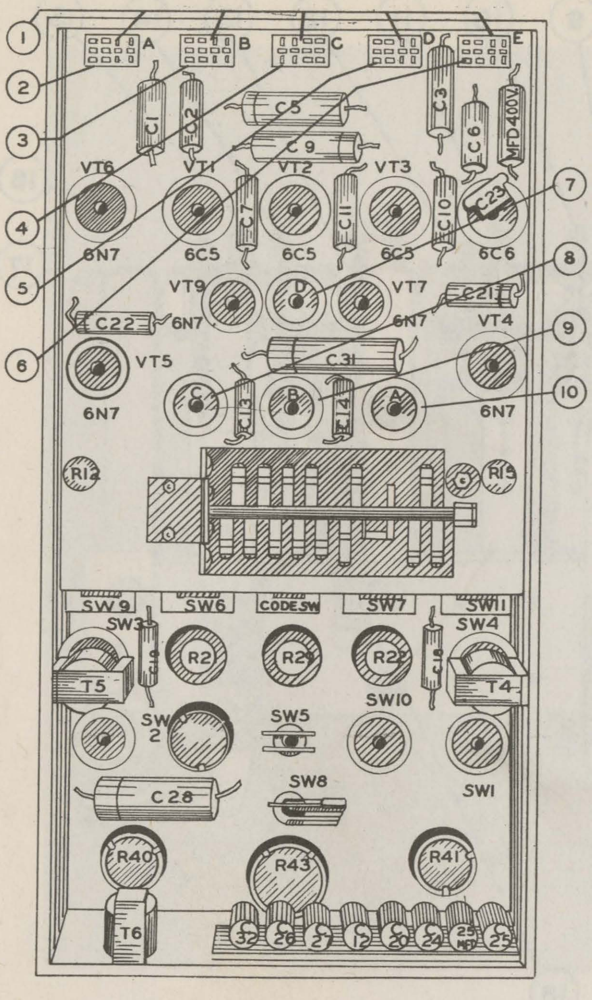

Figure 100—Radio Control Chassis—Bottom View

1. *12-Terminal Jones Connectors*
2. *To Right Transmitter*
3. *Cable "B" to Desk Junction Box*
4. *Cable "A" to Desk Junction Box*
5. *To Desk Power Supply*
6. *To Left Transmitter*
7. *A-N Identification Transfer Relay*
8. *Visual Marker Relay*
9. *Range Disconnecting Relay*
10. *Voice Disconnecting Relay*

nected across the secondary. (R7) and (C7) serve as a bias resistor and bypass for the cathode circuit.

3. THE 3000-CYCLE AND 800-CYCLE "Z" AND "FAN" MARKER OSCILLATOR.—This circuit consists of oscillator tube 6C5 (VT1), transformer (T1), (C1), (C2), (C3), (C4), (R1), (R2), (R3) volume control, (R4), and a code "on-off" switch. A conventional audio oscillator circuit with primary (T1) feeding back into the secondary of (T1) causes audio oscillation when the grid is properly biased by resistor (R2). Note that when the entire amount of (R2) is in the circuit, the total resistance is 503,000 ohms which offers too much bias for oscillation conditions; but when the 500,000 ohm end is shunted to ground, leaving only 3000 ohms as the cathode bias resistance, this reduces the bias voltage and permits oscillation to occur. A lead is taken off at this midpoint and fed to the key which grounds out the high resistance end of the resistor (R2) when keyed. Whether the 800-cycle or the 3000-cycle note is produced, depends on whether (SW10) is in the "off" position or on any one of the five marker positions which produces the 3000-cycle note. The signal is fed through (SW10) to the keyer from the slider arm of the volume control (R3) and another take-off is made through (C4) which feeds the signal into the RF oscillator terminal No. 5. Keying, for sending code signals, is done when (SW10) is in the "off" position and thus will produce an 800-cycle note.

4. THE 400-CYCLE OSCILLATOR FOR "INNER MARKER" SIGNALS.—The 400-cycle oscillator consists of "6C5" (VT5) oscillator tube, transformer (T3), condensers (C8), (C9), (C10), (C11), and resistors (R8), (R9), and (R10) connected in an oscillator circuit which produces a clear stable tone of 400 cps. (R9) and (C10) act as the cathode bias resistor and bypass circuit from which the grid takes its negative bias. (R8) acts as a plate load resistor and is connected in series to ground with (C8) from the plate. A low impedance take-off point between (R8) and (C8) is connected to terminal contact No. 5 of the left transmitter feeding the 400-cycle note into the grid of the amplifier section of the oscillator, thus producing a modulated 400-cycle note in the output of the transmitter which can be picked up by the fuselage radio receiver.

5. KEYER AND RANGE SWITCHING RELAYS. (*See figures* 101 *and* 199.)—The signal from the 1020-cycle range oscillator is fed from the low impedance point between (C5) and (R6) to the center contact of relay (D) from which it feeds to either the "A-N" cam contact side of cam switch No. 10 or to the common lead to identification cams Nos. 5, 6, 7, 8, and 9. Since relay contacts are closed during the time of sending identification signals, the oscillator signal is fed through the left side contacts of relay (D) to the common side of all identification cam switches. Switches (SW1) and

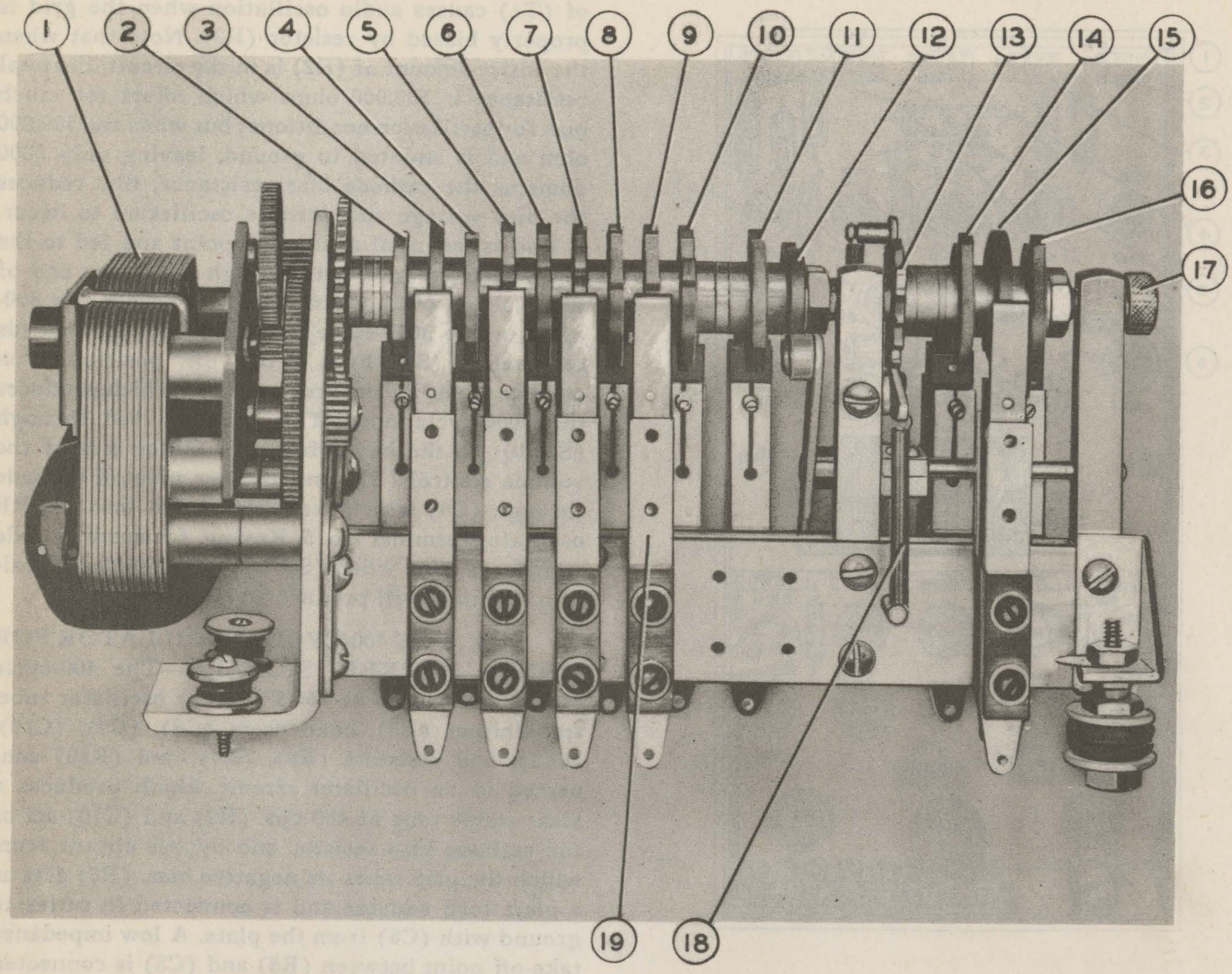

Figure 101—Radio Keyer Assembly

1. *Keyer Motor*
2. *No. 1 Fan Marker Cam*
3. *No. 2 Fan Marker Cam*
4. *No. 3 Fan Marker Cam*
5. *No. 4 Fan Marker Cam*
6. *"AZ" Cam*
7. *"BU" Cam*
8. *"DM" Cam*
9. *"SR" Cam*
10. *"SY" Cam*
11. *"A-N" Interlock*
12. *Step Cam*
13. *Keyer Ratchet*
14. *Switching Cam*
15. *Relay Cam*
16. *Switching Cam*
17. *Knurled Nut*
18. *Ratchet Pawl Spring*
19. *Keyer Contact Assembly*

(SW2) control the identification call letter sent. Contact arms of these switches are connected directly into the center contacts of cam (SW12) and (SW14) which control the side of the "A-N" mixer circuit to which the identification signals are fed. This circuit accounts for the sending of the call letters, first from the "N" quadrant antenna of the range station and the second call letter coming from the "A" quadrant antenna. During identification signals, relay (D) is operated by cam No. 13 on the slow speed shaft of the "keyer." Note that when identification signals are being sent the two single contacts of relay (D) are open, but when cam No. 13 "opens" relay (D) is released, and all contacts move to the right. This switches the oscillator signal to the right side of the double-pole relay switch and feeds it to the "A-N" cam switch for keying simultaneously "A-N" to both mixer and buffer amplifier circuits, while (D) contacts (4), (5), (6), and (7), close connecting the "A-N" cam switch

No. 10 to the "beam-shift" control of both amplifiers.

6. MARKER BEACON SYSTEM AND CONTROLS.—The 800-cycle 3000-cycle oscillator operates on 3000 cycles when the marker beacon selector switch is on any position except the "off" position. This signal is fed to one side of the four marker beacon interrupter cams. The marker beacon selector chooses the output of the desired cam and feeds this signal into the control chassis interphone amplifier. The output from this amplifier is fed into the radio output line when the "radio-interphone" switch (SW5) is in the "radio" position, hence the marker beacon signal is heard as radio output. When the visual marker switch (SW11) is "on," the cam output is not only fed into the desk interphone amplifier, but also into the visual marker amplifier. The output of this visual marker amplifier operates the visual marker relay (C5) which in turn operates the visual marker lamp. There is a push button switch in parallel with the marker beacon relay which will also operate the lamp.

7. RADIO CONTROL CHASSIS INTERPHONE AMPLIFIER AND RELAY.—The radio control chassis interphone amplifier consists of a "6V6" (VT8) amplifier tube, cathode bias, resistor (R30), bypass condenser (R30), output transformer (T7), and volume control (R28). The input to this amplifier is either aural marker output from (SW9), or desk microphone through the "radio-interphone" switch (SW5) and volume control (R28), or both. The output is tied to the instructor's and desk operator's earphones when (SW5) is in the interphone position. This output is tied to the fuselage radio output when (SW5) is in the "radio" position. When (SW5) is in the "radio" position, the desk microphone input is not fed to (VT8) but to (VT7) through the interphone relay [however, aural marker signals are still fed to (VT8)]. The two plate outputs of (VT7) are then used as modulation voltages at the transmitters for voice or voice-range operation. When the pilot's simultaneous-voice-range switch is on range, the interphone relay opens the input to (VT7), and there is no voice modulation signal applied to the transmitters. Thus, only range comes through.

8. VOICE-RANGE RELAY.—The contacts of this relay are usually closed in order to feed the beam signals into the No. 4 terminal contacts of the transmitter units. However, at times when "beam" signals are undesirable, the voice relay contacts can be opened by use of the pilot's simultaneous-voice-range switch located in the fuselage just above the pilot. The direct current which operates the relay is taken from a separate winding on the power transformer and rectified by a copper oxide rectifier.

9. THE BEAM SHIFT BUFFER AMPLIFIER AND CONTROLS.—A "6N7" (VT4 and VT5) amplifier tube is used in this circuit. The grids receive their signal voltage from the keyer through the "beam shift" control. This control is a dual control, connected in such a way in the circuit that the signal voltage to one grid is increased, while the signal voltage to the other grid decreases with a turn of the mixer control knob, and vice versa much in the same manner as a "fader." Since this control is dual and on one shaft, it can readily be understood that there will be a point where an equal amount of signal voltage is fed to both grids. Due to the "A-N" characteristics being equal in time but reversed as to continuity of the "dit" and "dah" originating from the same cam keyer switch "interlock," a continued signal is recognized as the "beam" or "on-course" signal. This signal appears at the plates of the tube and is fed through the centering control (R12) or (R15) to coupling condensers (C13) or (C14) (depending on which amplifier is under consideration) to the contacts of relay (B) and then No. 4 position of the radio transmitter terminal. In order to feed beam signals to the transmitter, it is necessary for relay (B) contacts to be closed.

10. NOISE AMPLIFIER AND CONTROLS.—The triode sections of the "6N7" (VT6) duo-diode amplifier tube are used as separate audio amplifiers. The inputs are fed through selector switches (SW3) and (SW4) which feed into the amplifiers a choice of radio "interference," "static," or broadcast reception for simulating radio direction finding on broadcast stations. When selector switches (SW3) and (SW4) are in the No. 1 position, condensers (C18) and (C19) are shunted across the primary sides of (T14) and (T15). When the switches are in either No. 2 or No. 3 position, condensers (C18) and (C19) serve as coupling condensers from the signal source, also as "stopping" condensers in cases where d-c voltages exist at the point of signal source. Otherwise, the primary winding might be damaged by excessive direct current. Volume is controlled by (R21) and (R22) which are shunted across the secondaries with the slider arms connecting directly into the grids. Input volume control prevents overloading at the

"grid," which goes toward producing a clear and stable note in the output circuit. (R23) and (C20) both serve as cathode bias resistors and bypass circuits. Both grids take their bias from negative voltage drop across (R23) and ground through (T4) and (T5) secondaries with their respective volume controls. (R19) and (R20) act as plate load resistors. The signal is fed from the plates through coupling condensers (C16) and (C17) to the "right" and "left" transmitter units through contact No. 7 to the radio transmitter unit.

(*c*) THE POWER SUPPLY. (*See figures 102 and 103.*)

1. CONTROLS.—The power supply produces a direct current supply for the above mentioned amplifiers and oscillators, the microphone, and for the localizer circuit. Controls on this unit are the localizer "on-off" switch and localizer zero set.

2. THE DESK POWER SUPPLY. (*See wiring diagram, figure* 200.)—The desk power supply consists of an electronic full wave rectifier and filter circuit providing 250 volts direct current for the radio chassis and transmitters; a dry stack rectifier and filter circuit supplying 20 volts direct current for the control chassis relays and desk microphone, and a dry stack rectifier and filter circuit supplying localizer voltages.

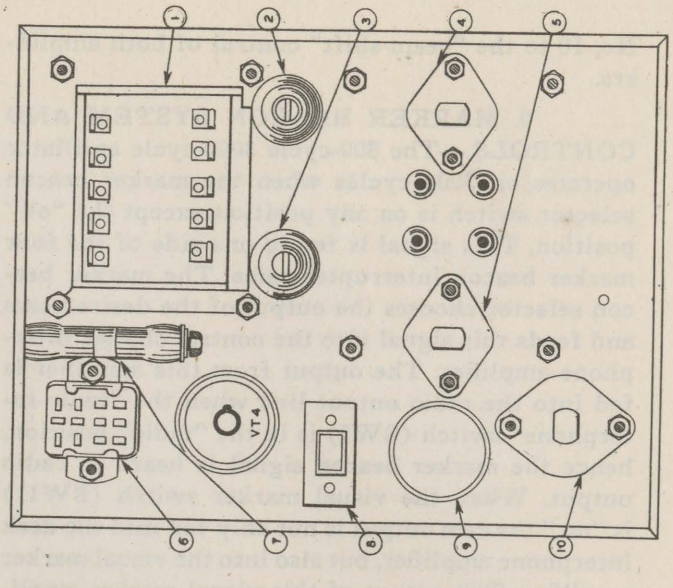

Figure 103—Desk Radio Power Supply—Bottom View

1. *Power Transformer*
2. *Mike & Relay Voltage Supply Stack Rectifier*
3. *Localizer Voltage Supply Stack Rectifier*
4. *Mike & Relay Voltage Supply Filter Condenser*
5. *Localizer Voltage Supply Filter Condenser*
6. *Plug Connector*
7. *B + Voltage Adjustment Slide*
8. *Localizer "On-Off" Switch*
9. *Localizer Zero Set Potentiometer*
10. *B + Filter Condenser*

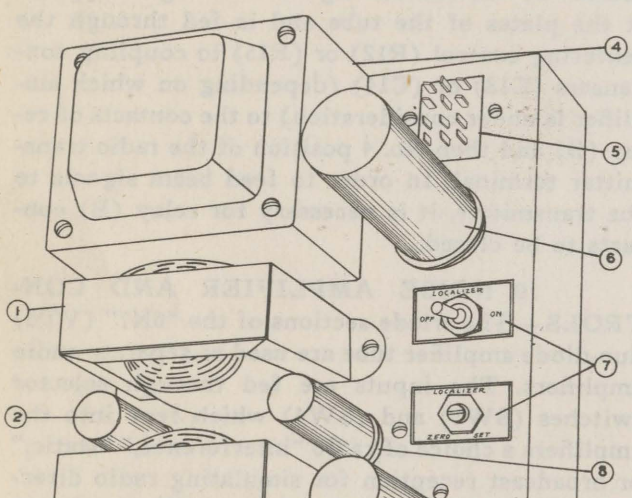

Figure 102—Desk Radio Power Supply—Top View

1. *B + Filter Choke*
2. *Mike Stack Rectifier Filter Condenser*
3. *B + Filter Choke*
4. *Power Transformer*
5. *Plug Connector*
6. *VT4*
7. *Localizer Controls*
8. *Localizer Voltage Filter Condenser*
9. *B + Filter Condenser*

NOTE

Voltages given are full load voltages. (Full load for the plate supply is 64 milliamperes.)

(*d*) THE PICK-UP GONIOMETER. (*See figures* 104 *and* 105.)—The pick-up goniometer unit contains a goniometer whose stator coils are fed by the transmitter unit and whose rotor direction is controlled by a teletorque in the unit. The pick-up goniometer unit contains a goniometer stator that is connected in parallel with the transmitter goniometer stator. The rotor of the pick-up goniometer is driven by a teletorque from a transmitter teletorque mounted on the instrument drive gear box, and controlled by the output of a differential whose primary is controlled by the Trainer heading and

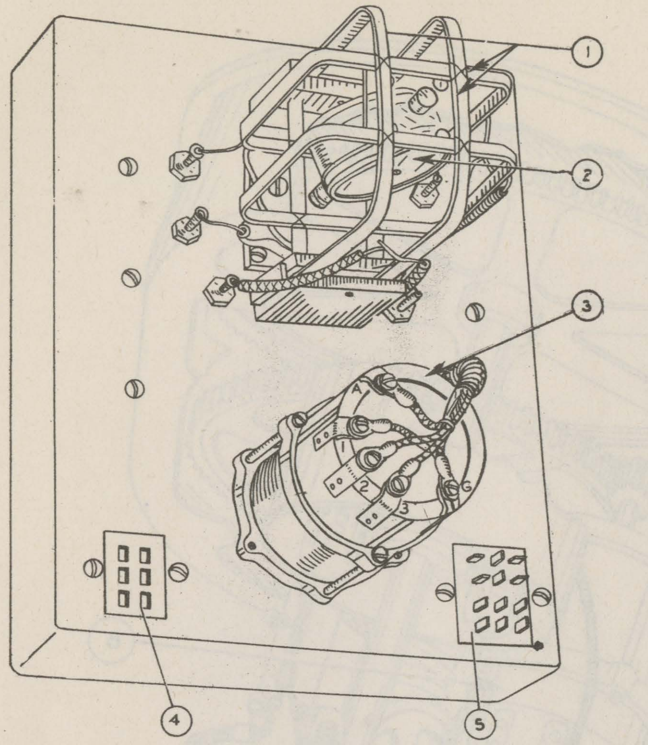

Figure 104—Receiver (Pick-up) Goniometer Unit—Top View (Cover Removed)

1. *Stator Coils*
2. *Rotor Coil*
3. *Loop Azimuth System Receiver Teletorque*
4. *6-Contact Jones Connector*
5. *12-Contact Jones Connector*

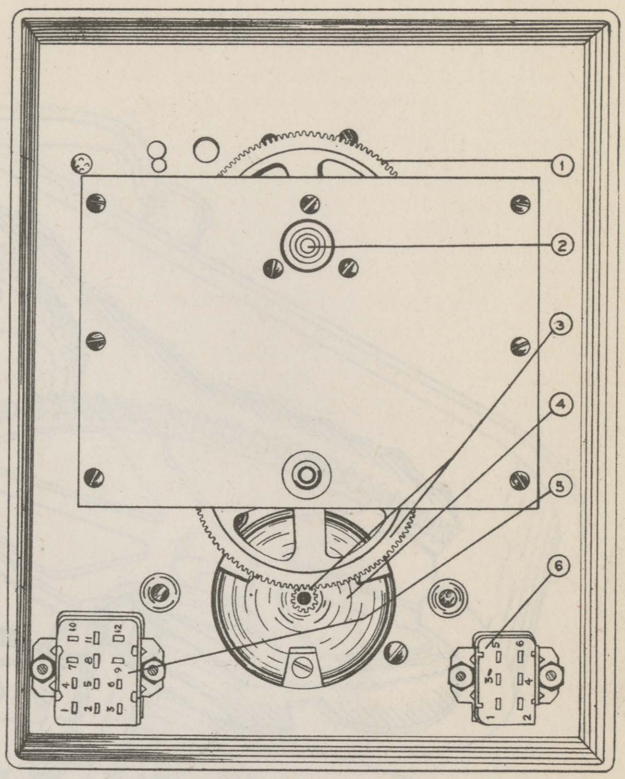

Figure 105—Receiver (Pick-up) Goniometer Unit—Bottom View

1. *Goniometer Rotor Drive Gear*
2. *Receiver Goniometer Rotor Shaft*
3. *Goniometer Drive Gearing*
4. *Loop Drive Receiver Teletorque*
5. *12-Contact Jones Connector*
6. *6-Contact Jones Connector*

whose spider is controlled by the radio operator's loop azimuth control. The omni-directional antenna provides sensing, as a cardioid reception pattern results when the receiving loop (the rotor of the pick-up goniometer unit) is coupled to the omni-directional antenna.

(*e*) THE RADIO DIRECTION FINDING SYSTEM. (*See figures* 84, 96, 97, *and* 104, *and wiring diagrams, figures* 202 *and* 203.)

1. The radio direction finding system consists of three goniometer units, two omni-directional antennae, two teletorques, two transmitter azimuth controls, a loop azimuth control, and a differential.

2. The two transmitter goniometers are located in the desk transmitter units. The rotors of these units are fed by the modulated transmitter signal and are directionally controlled by the azimuth control on the transmitter. The stator coils of these goniometer units feed in parallel to the stator coils of a third unit, or the pick-up goniometer unit. The rotor of the pick-up goniometer unit is controlled by a receiver teletorque mounted on the same unit.

e. THE RECORDER. (*See figures* 106 *and* 107.)

(1) The recorder travels over the graticule on three wheels. Two of them are drive wheels and the third is an "inking wheel" which leaves an inked track on the chart. Two teletorques are geared to the drive wheels and provide forward travel of the recorder.

(2) Directional control is obtained with another teletorque located in the center of the recorder. All three wheels are attached to an individual vertical shaft and at the top of each shaft is a large gear. The large gears mesh with the small pinion gear on the central teletorque. Thus when the center teletorque is turned, the three large gears

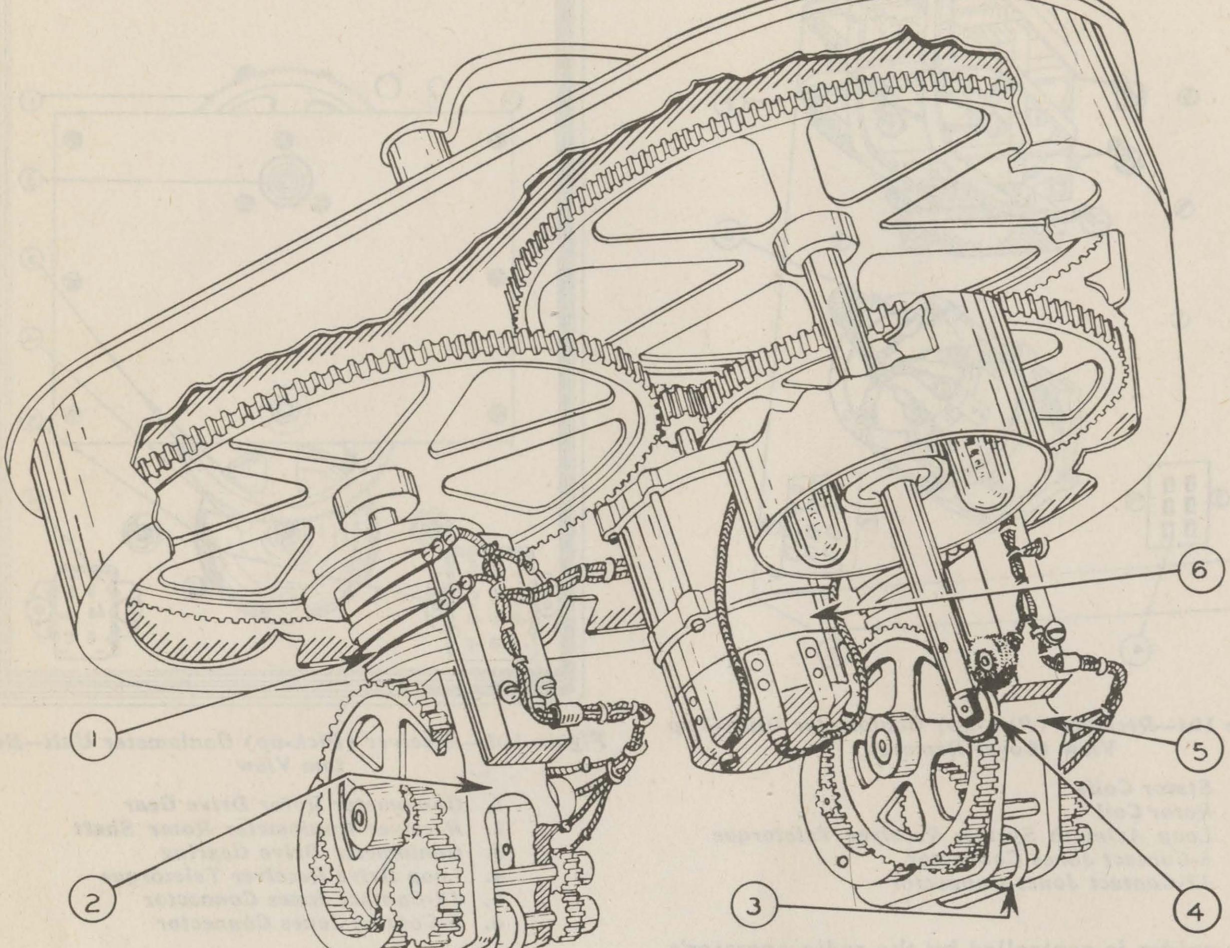

Figure 106—Desk Recorder

1. *Collector Rings*
2. *Drive Teletorque (Receiver)*
3. *Drive Wheels*
4. *Inking Wheel*
5. *Drive Teletorque (Receiver)*
6. *Track Teletorque (Receiver)*

and their shafts also rotate the three wheels. It will be readily seen that the three wheels should always be headed in the same direction.

(3) The teletorques are controlled by master track teletorques, and the master ground speed teletorque in the wind drift mechanism. [See Section III, par. *b*(3).]

(4) When the control desk master switch is turned on, the teletorques in the wind drift mechanism are geared to the track and ground speed outputs. Between the pinion gear and the large gears in the recorder, there is a gear ratio of 12 to 1. Consequently, when the teletorques "come alive" and line up with each other, the recorder will jump to the nearest one of 12 headings. If the recorder is properly synchronized, as described later, it will only be necessary at the start of each problem to spin the large gears around by hand until the inking wheel is headed in the same direction on the map as the Trainer fuselage is headed.

(5) The graticule used with the recorder is a chart covering the territory shown on the terrain projection plate. The movement of the projection plate and the recorder are both controlled from the same teletorque in the wind drift mechanism, so that the operator, noting the position of the re-

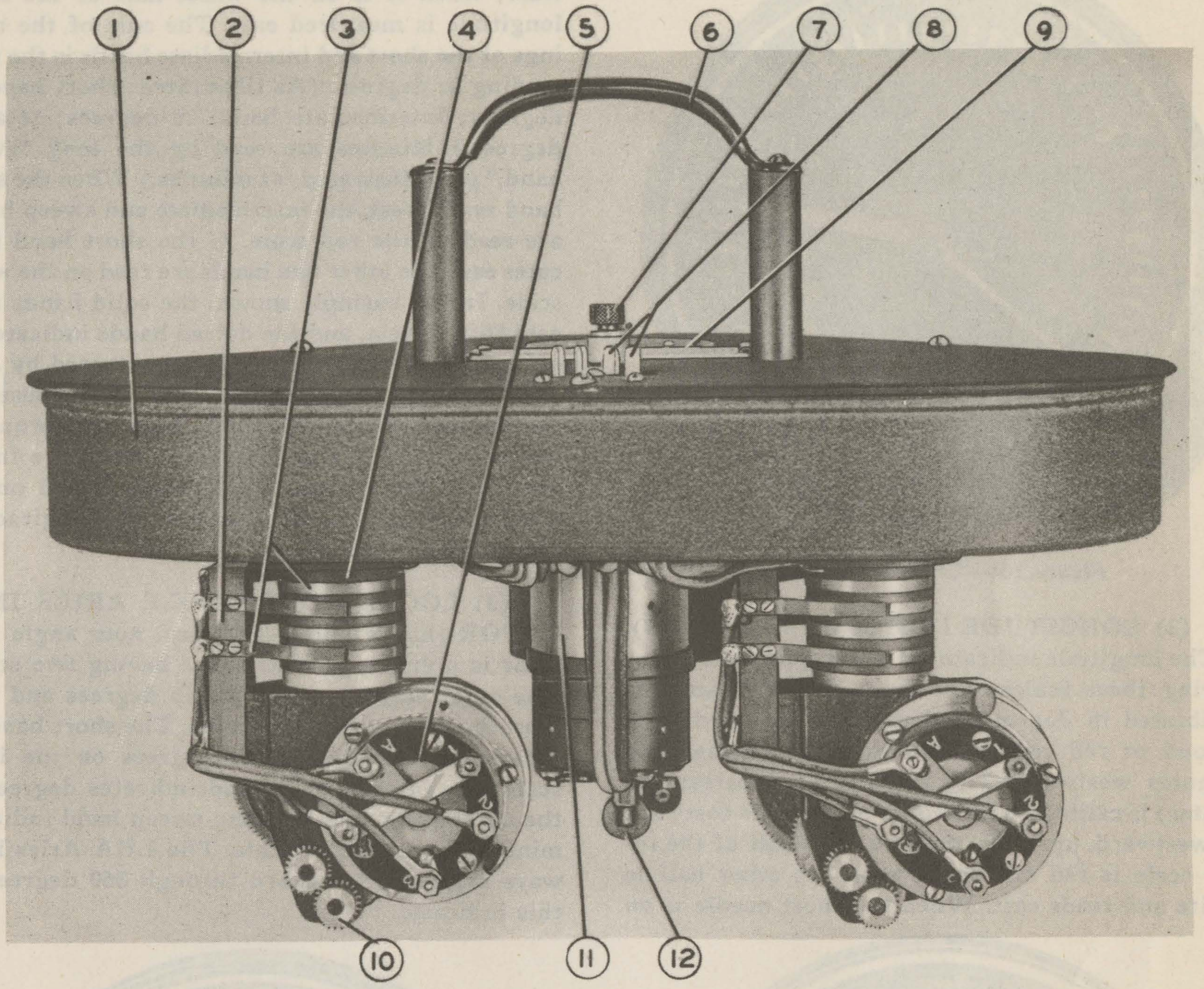

Figure 107—Desk Recorder—Rear View

1. *Recorder*
2. *Brush Block Assembly*
3. *Collector Ring Brushes*
4. *Collector Rings*
5. *Ground Speed Drive Receiver Teletorque*
6. *Recorder Handle*
7. *Thumb Nut*
8. *Jones Plug*
9. *Azimuth Pointer*
10. *Ground Speed Drive Gear Train*
11. *Track Receiver Teletorque*
12. *Inking Wheel*

corder on the chart, is informed of the position of the simulated aircraft over the ground.

f. DESK INDICATORS.—On the control desk instrument panel are mounted the latitude, longitude, and LHA Aries indicators, and a clock.

(1) LATITUDE INDICATOR (*figure* 108).—The latitude simulated by the dome position (up or down the rail) is shown on this instrument. The instrument consists of a teletorque, gear train, dial face and hands. The receiver teletorque in the instrument is driven electrically by a master or transmitter teletorque, located on the main gear box. [See Section III, par. 1*d*(10).] As illustrated, the latitude simulated by the dome is 42° 38′ N. The wide hand indicates degrees and the narrow hand indicates minutes. To synchronize the indicator with the position of the dome, the gear box may be set at the zenith of the rail and the indicator hands set to read 90° 00′ N, by use of the setting knob.

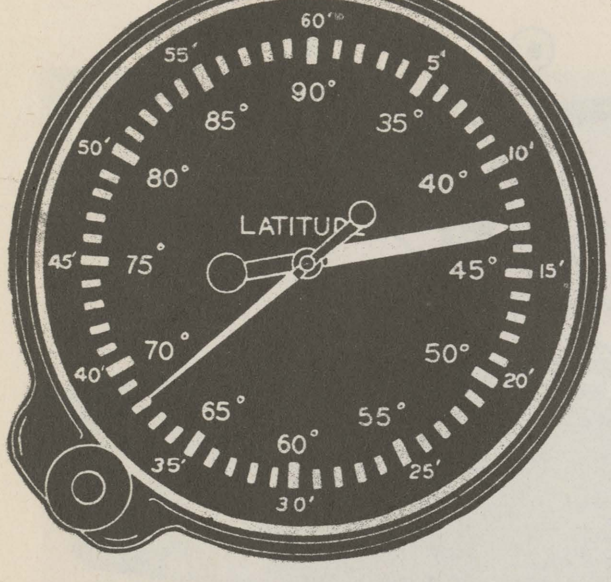

Figure 108—*Latitude Indicator*

(2) LONGITUDE INDICATOR (*figure* 109). —The longitude indicator is a dial type instrument having three scales. The outer or white scale is calibrated in degrees and minutes eastward. The second or red scale is calibrated in degrees and minutes westward. The third scale (nearest the center) is calibrated in 60 degree intervals eastward or westward, up to 180 degrees. One-half of the inner scale is red and reads west, the other half is white and reads east. When the short needle is on the red half of the scale, longitude is measured west; when it is on the white half of the scale, longitude is measured east. The sum of the readings of the short and intermediate hands is the total reading in degrees. (As illustrated: short hand, 60 degrees; intermediate hand, 26 degrees; total 86 degrees.) Minutes are read by the long "sweep hand." (As illustrated: 41 minutes.) When the short hand reads west, the intermediate and sweep hands are read on the red scale. If the short hand indicates east, the other two hands are read on the white scale. In the example shown, the solid hands indicate 86° 41′ west, and the dotted hands indicate 86° 41′ east. The indicator hands are actuated by a receiver teletorque through a gear train housed in the instrument case. The transmitter teletorque receives its motion from the longitude drive in the gear box. The setting knob, when pulled out, is used to manually set the hands to the longitude of the problem being set up.

(3) LOCAL HOUR ANGLE ARIES INDICATOR (*figure* 110).—The local hour angle indicator is a dial type instrument having two scales. The outer scale is calibrated in degrees and minutes, the inner scale in degrees. The short hand indicates in multiples of 60 degrees on the inner scale; the intermediate hand indicates degrees on the outer scale, and the long sweep hand indicates minutes on the outer scale. The LHA Aries is always measured westward through 360 degrees on this indicator.

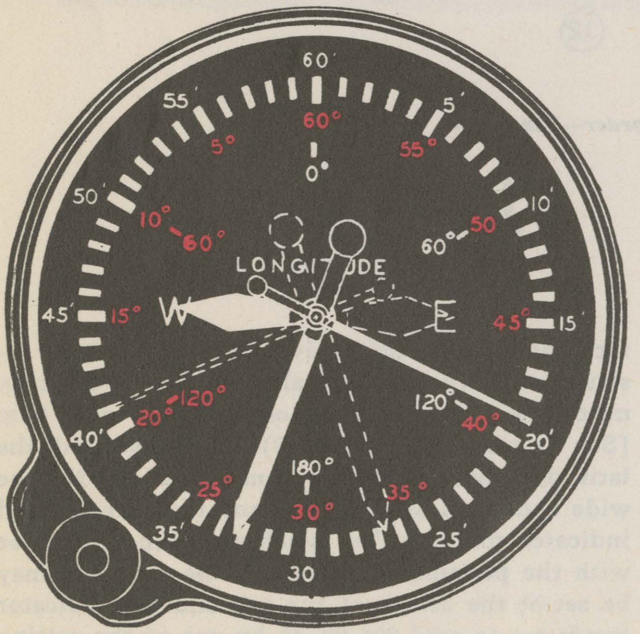

Figure 109—*Longitude Indicator*

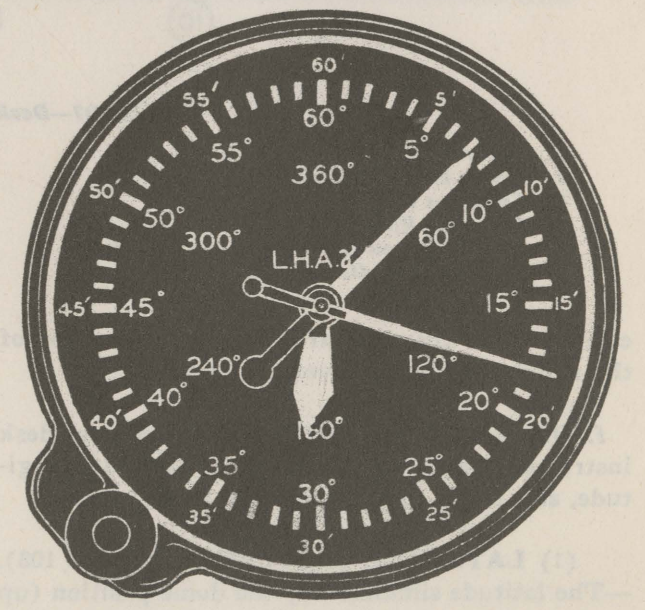

Figure 110—*LHA Aries Indicator*

(*a*) A specific example, in which the LHA Aries is 187° 18′, is illustrated. This reading is obtained by adding the short hand indication (180 degrees) to the intermediate hand indication (7 degrees) in order to obtain the total number of degrees (187 degrees), and by reading the minutes indicated by the sweep hand (18 minutes).

(*b*) The indicator hands are actuated by a receiver teletorque through a gear train housed in the instrument case. The transmitter teletorque receives its motion from a gear train on the dome hub.

(*c*) The setting knob, when pulled out, is used to manually set the hand to the LHA Aries (rotary position) of the dome for a specific time and longitude.

(4) CLOCKS (*figure* 111).—Three clocks are driven by the time transmitter teletorque: one at the operator's desk, one in the navigator's panel, and one on the right side of the pilot's panel, making it accessible to both the pilot and radio operator. The illustration is a facsimile of the clock. There are three hands: an hour hand, a minute hand, and a sweep second hand. The dial is essentially the same as a standard clock. The outside figures indicate seconds or minutes, the large inside figures indicate hours; and the small inside figures indicate hours (24-hour clock). This 24-hour dial facilitates reading time for the purposes of conversion to Greenwich time or to enter any of the various navigational tables. A setting knob is located at the lower left corner.

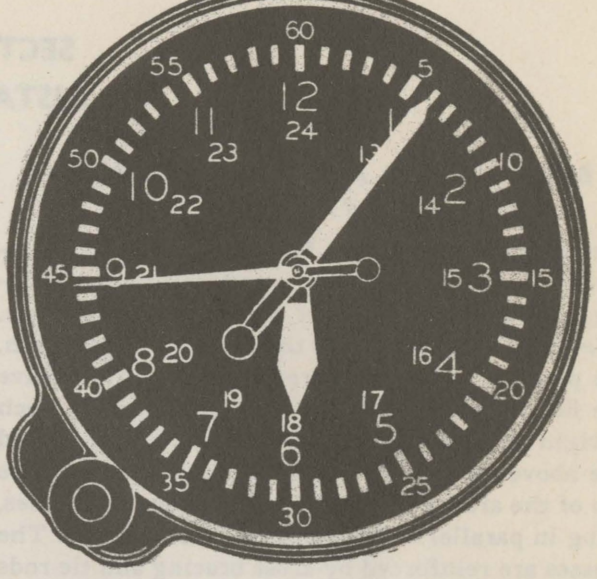

Figure 111—*Clock*

SECTION IV
INSTALLATION

1. BUILDING SITE AND FOUNDATION.
(*See figures* 1 *and* 2.)

a. BUILDING AND MAIN STRUCTURE.—The Trainer is housed in an octagonal-shaped building, approximately 22 feet across by 45 feet high. The main structure takes the form of a steel arch, the peak of which is approximately 40 feet above the floor. This arch is made in six sections, each upright consisting of two identical sections bolted one above the other to form a single column. The top of the arch is formed by two triangular trusses, lying in parallel and joining the two uprights. The trusses are reinforced by cross bracing and tie rods and the rail supporting the celestial dome is supported by brackets on the north column and on the truss cross brace.

b. ALIGNMENT OF FOUNDATION AND BUILDING.—The foundation, building and main structure are, where feasible, aligned as follows: the plane of the columns and arch is aligned as closely as possible with magnetic north and south so that the dome rail lies in this plane. Although this alignment is desirable, the Trainer will operate equally well with any other alignment. In any case, the basic reference in locating points within the building is that the dome rail **does** theoretically run north and south, with the lower end attached to the north column. As all references to location in this Handbook will be made in terms of the cardinal and inter-cardinal points of the compass, care should be taken to orient these directions correctly when locating any point by referring to the north column, or the plane of the dome rail. The entrance or anteroom lies on the east side of the building; the dome counterweight on the south side, and the stairs and operator's control booth on the west side. The site for the building foundation should be chosen carefully, keeping away from filled land if possible. Settling of the piers which support the columns would necessitate realignment of the main structure and might possibly cause damage by distorting the dome rail.

NOTE

In the event that the specifications for locating the building as outlined above do not fit in with the general plan of other buildings, the Trainer unit may be placed as desired. However, in selecting any other alignment than as outlined, the whole structure, including foundation, towers, and buildings, must be rotated in order to preserve the exact relationship of the various units with each other. Any inversion of the building from left to right will seriously affect this relationship and offer difficulties in adjustments.

c. INSULATION.—The concrete piers for supporting the main structure are insulated from the floor and walls. The main purpose of the insulation is to prevent any deflection of the building caused by high winds, vibration set up by powerful motors or other sources, from being transmitted through the building to the main structure supporting the celestial dome, etc. All details for laying the foundation will be found in the engineering specifications supplied by the respective services.

d. AIR CONDITIONING.—The building must be air conditioned to assure proper operation of the Trainer. Changes in temperature may vary the adjustment of the Trainer. Recommended operating temperature is 21° ± 3° C. (70° ± 4° F.).

e. LIGHTPROOFING.—Every precaution should be taken to make the building lightproof so as to obtain the maximum efficiency of operation of the Trainer. A small amount of light leading into the building interior will greatly detract from the results to be obtained.

f. PAINTING.—All painting should be completed by those responsible for the erection of the building before the Trainer installation is begun. A dull black, or preferably a blackboard paint, is recommended for the entire interior wall surfaces from the peak of the roof down to the floor. This will minimize the possibility of any light reflection. The interior of the operator's booth may be painted a light color in the interest of pleasant surroundings and improved lighting. The floor of the building may be painted with any standard battleship grey floor enamel.

g. POWER SPECIFICATIONS.

(1) The Trainer power supply is 225 volts **single phase** (center wire neutral), and 115 volts at 60 cycles. (Special Trainers are made to operate on 50 cycles.)

(2) The turbine demand is 2.5 kva at 225 volts. This is the only Trainer unit which operates at 225 volts. It is important that the turbine voltage be maintained at 225 volts ± 5 volts during operation because the vacuum output of the turbine drops very rapidly with a decrease in turbine voltage. A low voltage will therefore cause sluggish controls. A high voltage will considerably decrease the life of the turbine motor and is undesirable from that standpoint.

(3) The remainder of the Trainer units operate either directly or indirectly from 115 volts and the demand is approximately 3.0 kva. Low voltage is undesirable because units such as the telegon oscillator do not operate satisfactorily under this condition, while excessive voltage will decrease the life of various electrical units. Voltage variations lead to different dome movements with the same setting on the dome speed controls. A change in frequency will lead to variation between Trainer clocks and the watches of Trainer personnel.

(4) In view of the above facts, the following are the recommended power specifications:

Voltage	*Frequency*	*Kva Demand*
225 ± 5 volts	60	2.5
115 ± 3 volts	60	3.0

(5) This, however, does not include the power demand of the air conditioning equipment. The air conditioning contractors will supply complete information on this phase of the Trainer supply.

2. TRAINER UNPACKING PROCEDURE.

a. The Trainer comes completely packed in twenty-two reinforced wooden boxes. Each box is plainly numbered and its contents listed in form of part numbers on the top. The top and sides are marked as such.

b. The following is a list of the boxes, their general contents, size, number, and weight:

No.	*Contents*	*Size*	*Weight*
1	Rails (guard) and work bridges	15′ x 54″ x 41″	1365 lbs.
2	Hanger and pin assembly	39″ x 24″ x 11″	367 "
3	Bracket and pin assembly	33″ x 19″ x 18″	260 "
4	Dome rail assembly	15′6″ x 3′7″ x 1′2″	1500 "
5	Sector assembly	13′5″ x 2′4″ x 1′2″	570 "
6	Sector weights	3′4″ x 2′ x 11″	665 "
7	Latitude drive and reset assembly	20″ x 20″ x 14″	158 "
8	Dome gear box	3′4″ x 2′8″ x 3′8″	397 "
9	Dome ribs and screen	12′11″ x 60″ x 29″	800 "
10	Collimators	28″ x 32″ x 24″	800 "
11	Operator's control desk	68″ x 40″ x 35″	678 "
12	Operator's control desk instrument panel	48″ x 35″ x 8″	176 "
13	Radio	38″ x 38″ x 33″	445 "
14	Base frame assembly	11′6″ x 8′6″ x 68″	4430 "
15	Tower assembly	No standard crate	300 "
16	Fuselage	11′ x 5′10″ x 6′5″	1805 "
17	Wind drift assembly	33″ x 28″ x 12″	145 "
18	Projection screen (irregular)	10′ x 14′ x 1′	375 "
19	Terrain base frame	79″ x 41″ x 24″	5516 "
20	Counterweights	2′8″ x 2′8″ x 9″	835 "
21	"	" " "	672 "
22	Trainer tool box	20″ x 20″ x 14″	95 "

c. In opening these boxes the following precautions must be noted:

(1) Box No. 8 must be opened carefully. The top should be removed first, then the nails holding the 2- by 4-inch braces removed with a puller from the outside. Then lay the box on its side and slide the dome gear box out gently.

(2) Boxes No. 14 and No. 16 must be opened by taking the sides off first. In box No. 14 the base frame is fastened to the floor of the box by lag screws. These boxes are equipped with skids and may be moved without rollers.

(3) In removing the lids from boxes No. 12 and No. 19, it would be safer to use a nail puller rather than to pry the lids off, as the clearance between the top of the box and breakable instruments is less than 1/2 inch.

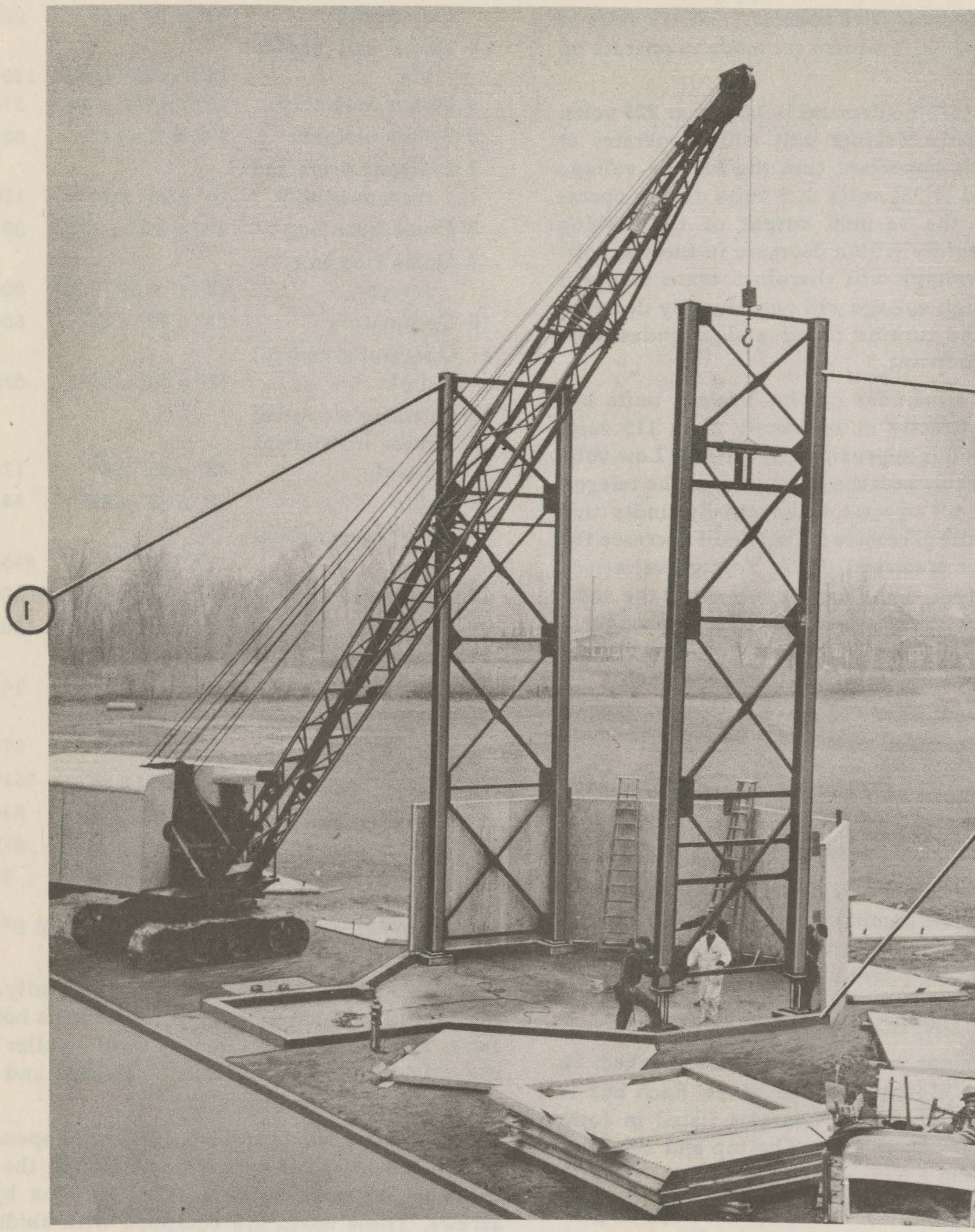

Figure 112—Locating Steel Columns

1. *South Steel Column*
2. *North Steel Column*
3. *Concrete Foundation*

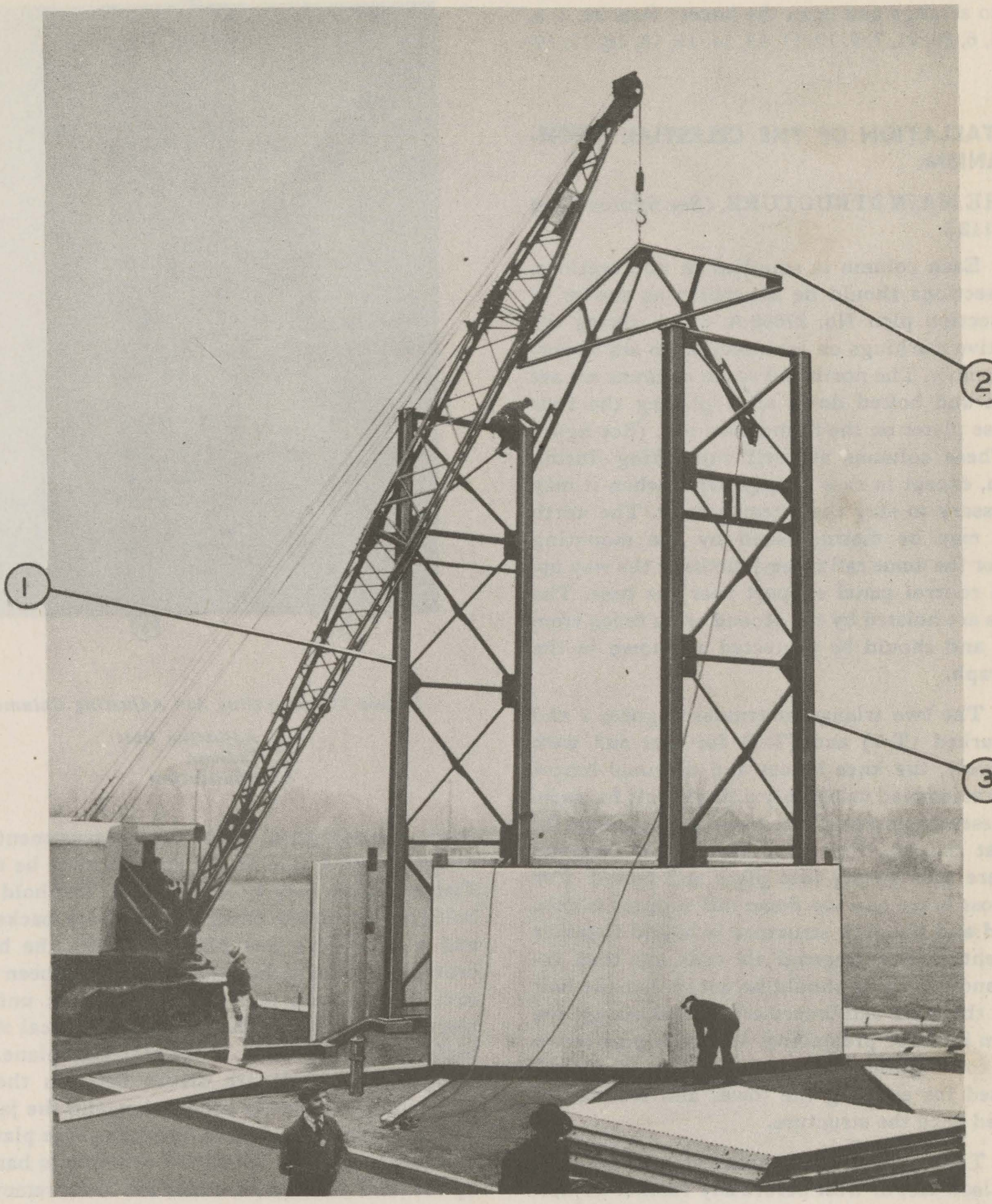

Figure 113—Erecting Main Structure

1. *South Steel Column*
2. *Triangular Steel Truss*
3. *North Steel Column*

(4) In all installation procedures the following order of numbers is the most convenient in which to arrange and open the boxes: Nos. 22, 1, 2, 3, 4, 8, 5, 6, 20, 21, 7, 9, 10, 11, 12, 14, 15, 16, 18, 17, 19, 13.

3. INSTALLATION OF THE CELESTIAL MECHANISM.

a. THE MAIN STRUCTURE. (*See figures 2 and 112.*)

(1) Each column is supplied in two sections. These sections should be assembled as shown in steel erection plan No. 27000 A which shows the destinative markings on each section to aid in correct assembly. The north and south columns are set in place and bolted down after placing the four steel base plates on the foundation pad. (See figure 112.) These columns are self supporting during erection, except in case of high wind when it may be necessary to stay them temporarily. The north column may be distinguished by the mounting flange for the dome rail three-fourths of the way up, and the control panel support near the base. The columns are hoisted by the second cross brace from the top and should be protected as shown in the photograph.

(2) The two triangular trusses (figures 2 and 113), marked (T-1) and (T-2) for east and west respectively, the knee braces and diagonal braces are next assembled using only a single bolt for each. The trusses are lowered into place and temporarily bolted at the top. The knee braces and diagonal braces are then swung into place and bolted. The truss cross brace and top dome rail support is then installed and the arch structure is bolted together permanently. The diagonal tie rods are then installed and set up. It should be noted that the bolt holes in the truss and braces are drilled out of line 3/8 of an inch for preloading, and drift pins are to be used for aligning the bolt holes. The "dardelet" bolts used for erecting the tower and trusses are furnished with the structure.

(3) The main structure must stand vertically and not lean east or west before any further adjustments can be made. Columns are located in the east-west direction. The method of checking the column (figure 114) is to suspend a plumb line from a board clamped to a flange of a column near the top of the column. The plumb line is located 3 inches (recommended) from the side of the column at the top, and the distance from the column at the bottom is measured. A comparison of the two measurements will indicate which side of the column must be raised. Either column may be leveled first. The hold down bolts on the tower being adjusted are backed off, and a structural jack placed beneath the bottom crosspiece close to the column which has been found low. The column is raised by the jack until the plumb line indicates the column is vertical ± 1/16 inch on the plumb side, in the east-west plane. Steel wedges (provided) are driven between the base plate and the concrete foundation, and the jack removed. Concrete is floated under the base plate and allowed to harden. When the concrete is hard, set up the hold down bolts, check the level, remove the wedges, and patch the holes. The second column is leveled in a similar manner.

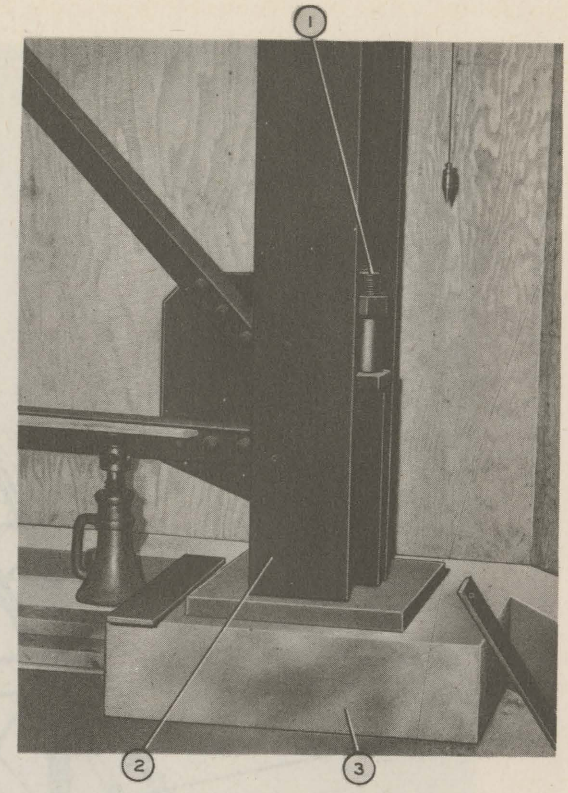

Figure 114—Leveling and Adjusting Column

1. *Adjusting Bolt*
2. *Column*
3. *Foundation*

b. WORK BRIDGES.

(1) The first step is to install and securely fasten the platforms marked "bridge platform" to the second cross beam from the top on the north

and south steel columns with the bolts provided for that purpose. These platforms are underbraced with triangular steel sections and are made of 1- by 4-inch planking, forming stations at which the celestial dome rail bridge is mounted, and which may be used as a landing step to and from the bridge. The erection of the bridge is facilitated by means of a pulley mounted at the top of the steel structure. The bridge is made of wood and is therefore relatively light. The simplest method of fitting the bridge is to tie a rope around the middle of the bridge and hoist it in the east-west plane with respect to the dome rail (figure 115). When at the top of the building, swing the bridge to the north-south plane and slacken the line slowly until the bridge rests on the bridge platforms. Fasten the bridge to the platforms from the under side with the proper screws and install pipe railing along both sides of it.

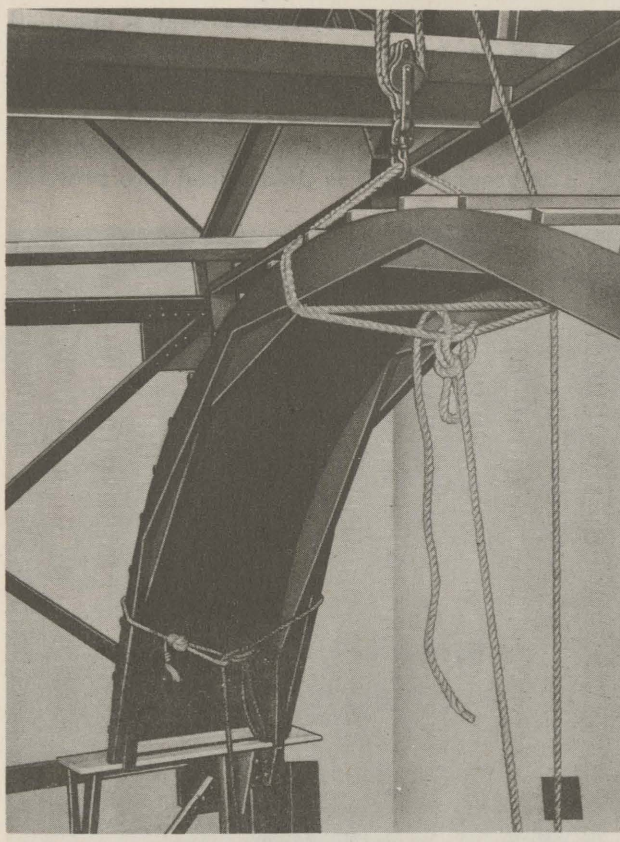

Figure 115—Hoisting the Celestial Dome Rail Bridge

(2) The second step is to install the service bridge. This is in the form of a curved ladder which is fastened on the south end of the dome rail bridge and adjacent to the east side of it. The slats of this ladder are leather padded, permitting a man to lie on it and work on the dome through the slats. The lower end of the service bridge is held in place by a bracket attached to the south steel column, and a carriage bolt through both bridges tying them together. The upper end is supported by two steel straps lagged to the ceiling of the building, and by a pipe clamp and bolts around the pipe rail which is installed along the side of the dome rail bridge. The service bridge can easily be hoisted into place, with the use of a rope and pulley suspended from the upper steel structure, and care should be taken to install the lower end of the ladder so that its curved surface is the same height as that of the dome rail bridge. This is done in order to provide sufficient clearance for movement of the celestial dome.

c. THE CONTROL BOOTH.—The booth is assembled against the west wall, with respect to the dome rail, of the Trainer building. The booth must

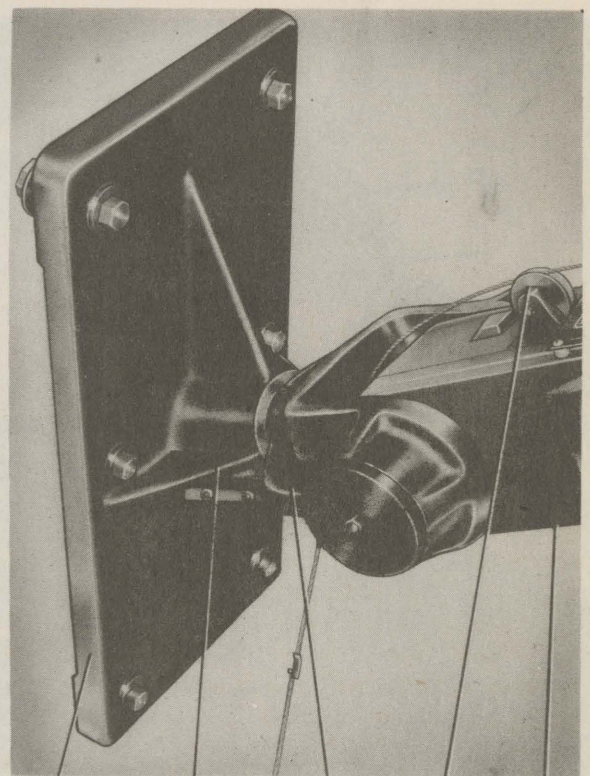

Figure 116—North Dome Rail Bracket Assembly

1. *North Bracket*
2. *Split Collar*
3. *Fork*
4. *Latitude Drive Cable Pulley*
5. *North End of Dome Rail*

be assembled around the control desk after the desk has been placed ready for use. (See section IV, par. 3 *l*.) The construction of the booth is similar to that of the building. The blackout curtains must be installed and their operation checked.

d. THE DOME RAIL BRACKETS. (*See figures* 116 *and* 117.)

(1) The first step is to assemble and install the lower or north bracket, which is attached to the north tower. This bracket consists of two parts, the bracket itself which is attached to the tower by six 3/4- by 3-inch bolts, and a fork to receive the dome rail, which fits into the bracket and is held by a split collar tightened by two bolts. These two parts are best assembled and raised together, but they may be put up separately if desired. The bearing for the fork must point upward and the small pulley must be on the west side when this bracket is correctly installed. The bolts holding this bracket are inserted so that the nuts face the wall, and they are then tightened temporarily. The bolts holding the collar of the fork should be left loose until the dome rail jig is fitted. This bracket can be raised most easily by a block and tackle suspended from a suitable wooden beam laid across the steel trusses overhead.

(2) The top bracket or south dome rail support (figure 117) is attached to the cross brace, supported between the two overhead trusses. It is held by two special bolts installed in the holes provided in the bottom of this cross brace. The unthreaded sections of these bolts indicate the top, and lie inside the supporting brace. These bolts must be first installed and locked into position by a nut on the top and one on the bottom of the support. A third nut must be run up on each bolt, to be used later to clamp the bracket at the desired position up and down on the bolt. The bracket itself is then raised into position

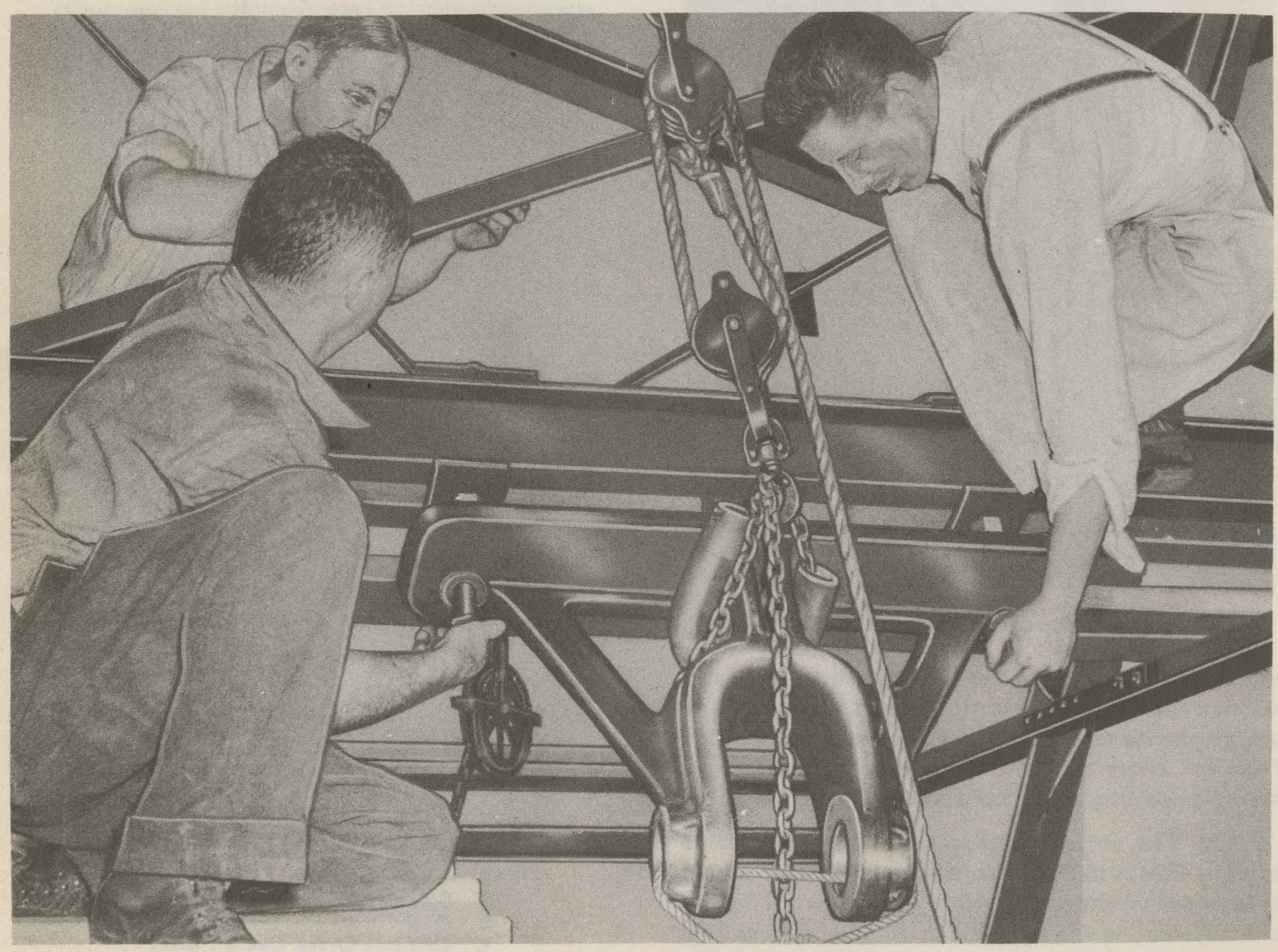

Figure 117—Hoisting Dome Rail Bracket

by a block and tackle attached to the steel structure overhead, and it is held loosely on the two bolts by two nuts preparatory to fixing its position to the dome rail jig. Two tapped holes to hold the zenith stop on the fork of the south bracket are positioned on the north face of the bracket. After the two brackets have been put in place the dome rail jig should be carefully checked for alignment with the dome rail. This should be done by placing the jig on top of the dome rail (on the floor) and adjusting the movable end fitting until the surfaces of the jig and the rails are parallel. The rail and jig may be pinned together to fit for length by using the dome rail pins (figure 118).

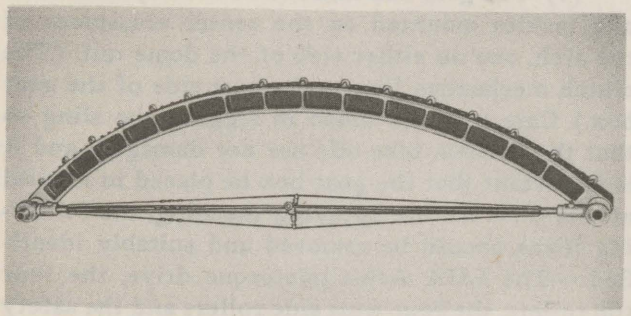

Figure 118—Dome Rail Jig

NOTE

The pins must fit easily, and the surfaces must be clean and free from all grease and dirt. With the jig and rail pinned together, tighten the setscrews on the adjustable end, and collar, and then remove the pins. The jig may be raised by the rope attached to its center, if guide ropes are tied to the end. The lower end of the jig should be pinned to the north bracket first.

(3) There are two adjustments which may be made to the upper bracket:

(*a*) The whole cross brace supporting the bracket may be swung back and forth as the bolts holding it to the trusses go through slotted holes. This adjustment brings the centers of the brackets nearer to, or farther apart, from each other.

(*b*) The bracket may be raised or lowered on its two supporting bolts either to adjust the elevation or the angle of the axis holding the jig.

(4) After both brackets have been adjusted so that the jig can be held in place by the pins (figure 119), there are two checks which must be made. The axis of the pins must be horizontal, and this is verified by checking with a level to see that the machined side surface of the upper bracket is vertical, as it is at right angles to the axis of the pins (figure 120). Secondly, a level should be used to make sure that the jig forms an angle of 64° with the vertical. This is checked by protractor level or by placing the level on the bracket which is assembled onto the jig. After these two conditions have been satisfied, the bolts holding the lower bracket should be tightened and the cross brace supporting the upper bracket should be tightened to the trusses. The nuts on the top side of the upper bracket should be left loose, so that this bracket may be slid up about one inch to provide sufficient flexibility to permit the installation of the dome rail. The cross brace will probably have to be as far south as possible. It should be noted that some adjustment may be ob-

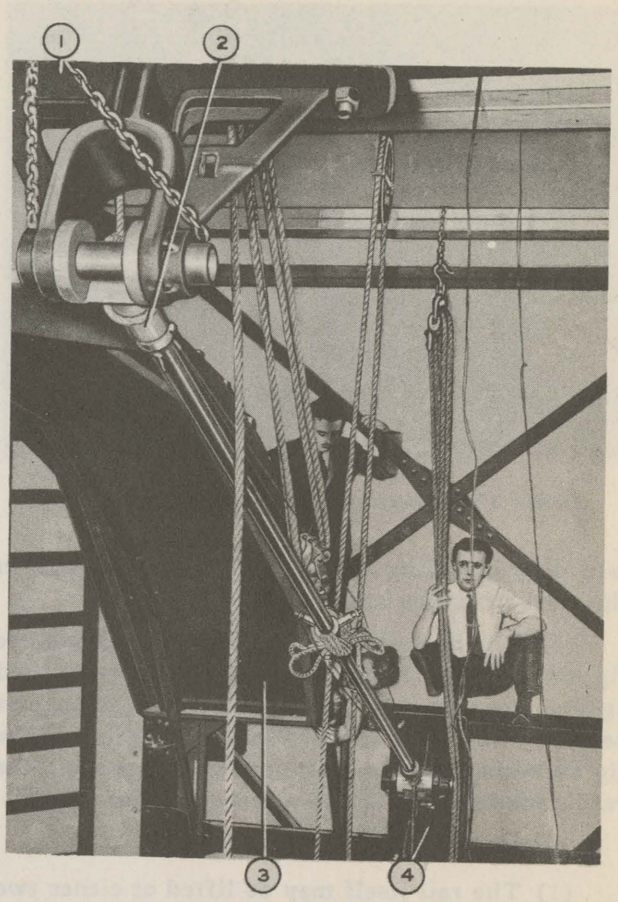

Figure 119—Checking North and South Brackets with Dome Rail Jig

1. ***South Dome Rail Bracket***
2. ***Rome Rail Jig***
3. ***Dome Rail Bridge***
4. ***North Dome Rail Bracket***

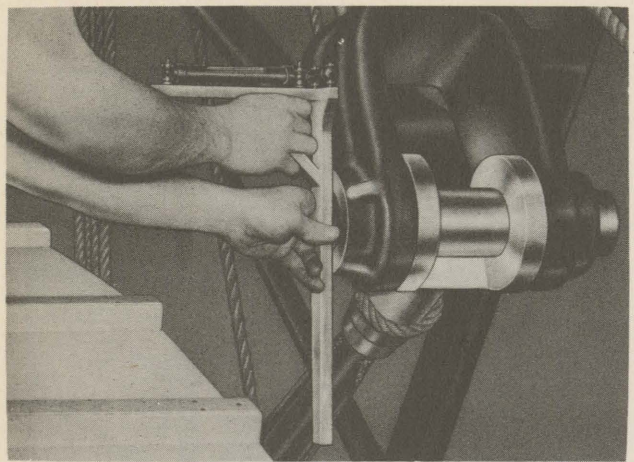

Figure 120—Checking South Bracket for Level

tained by changing the tension of the tie rods in the steel structure itself.

(5) The pins should now be removed and the jig lowered back to the floor where it is rechecked against the dome rail to make sure that it has not been thrown out of adjustment by handling. If the jig rechecks with the dome rail for alignment, the two brackets are now ready to receive the rail.

e. MOUNTING THE DOME RAIL.

(1) The rail itself may be lifted at either two or three points, depending on the equipment available. If two points of suspension are used, they must be equidistant from the center, but close enough in so that the center gravity of the rail is below the suspension points in order to prevent any tendency of the rail to turn over. If three points are used, the third point should be at the center. It should be remembered that the rail weighs nearly half a ton so that care should be taken in lifting it. If two block and tackles are used to hoist the dome rail, one block should be attached to the center cross brace of the truss structure, and the second block to wooden planks across the trusses, approximately 30 inches from the north tower.

NOTE

Take care to hang the north block high enough to permit raising of the rail. It will be necessary to tie the planks in place to prevent slippage. If three block and tackles are to be used, the method of suspension should be modified as required.

(2) Special clamps are provided with each Trainer for use in hoisting the dome rail. These aluminum clamps must be set up firmly to prevent slippage, as it will be necessary to pull the rail in a north-south direction when inserting in the brackets. The north, or lower, end of the rail should be pinned in place first, with the spike holes of the latitude teletorque on the **west** side of the rail. The rail may next be raised and pinned into the south bracket. Two caps with a through bolt are provided for each pin to prevent them from being pushed out of place. It is not necessary to make any adjustments to the rail at this time.

f. MOUNTING THE GEAR BOX. (*See figure* 121.)

(1) The gear box must be hoisted by two block and tackles mounted on the center crosspiece of the arch, one on either side of the dome rail. (The clutch mechanism lies on the east side of the gear box.) Care must be taken in rigging the sling so that the various take-offs are not damaged, and it is important that the gear box be placed in neutral at this time. Before applying the sling, the following items should be removed and suitably identified:—The LHA Aries teletorque drive, the four top rollers, the four west side rollers and the safety

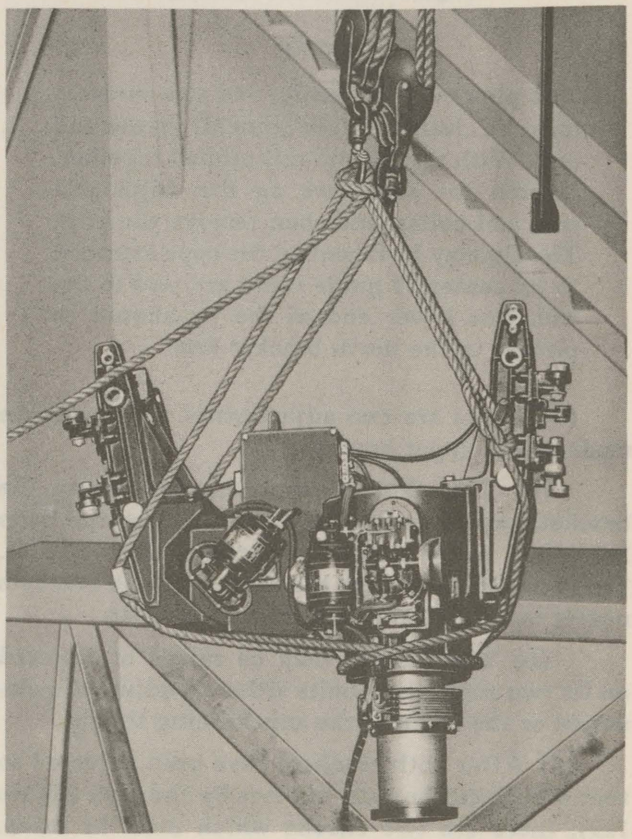

Figure 121—Hoisting the Dome Gear Box

pawls. Remove the brush block attached to the gear box and then remove the four screws holding the slip rings to the main shaft. The slip ring assembly will then come off with the dome hub.

NOTE

If the gear box is securely suspended, the celestial dome may be mounted on the hub before installing the gear box on the rail. No accessories are removed from the gear box in this event. The complete assembly is then hoisted to the rail.

(2) The gear box is then hoisted a convenient distance above the floor and the dome hub removed, using the special wrench and puller provided. The gear box must be guided carefully into place to prevent damaging the machined surfaces of the rail, and disturbing the bottom and east (reset mechanism side) side rollers, which are adjusted at the factory. Replace the top rollers by means of the cam adjustment, and attach the safety pawls.

g. ADJUSTING THE RAIL AND GEAR BOX.

(1) LEVELING THE DOME RAIL.—The dome rail must next be leveled in the vertical plane with the gear box at the top of the rail, using the special level provided for this purpose (figure 122). The rail should be checked at three positions, top, middle, and bottom. The rail is aligned by first twisting the fork in the lower mounting bracket and then removing the twist in the rail. The tolerance for this adjustment is ± 1 minute.

(2) LOCATING THE ZENITH OF THE RAIL.—The next step is to locate the zenith of the dome rail. This is done by using the special level fixture and marking the dome rail as indicated by the pointer beneath the level. The center of the dome shaft is marked on the top machined surface of the gear box and is aligned with the zenith by placing a square on the gear box. The zenith stop, mounted on the top bracket, is next adjusted to hold the gear box exactly at the zenith.

(3) LEVELING THE GEAR BOX.—Before leveling the gear box, the rail, rollers and the sides of the gear box where the level is to be placed must be carefully cleaned, removing the paint if necessary (figure 123). The gear box is leveled by placing the special level on the machined surfaces at the west side and north end of the gear box and ad-

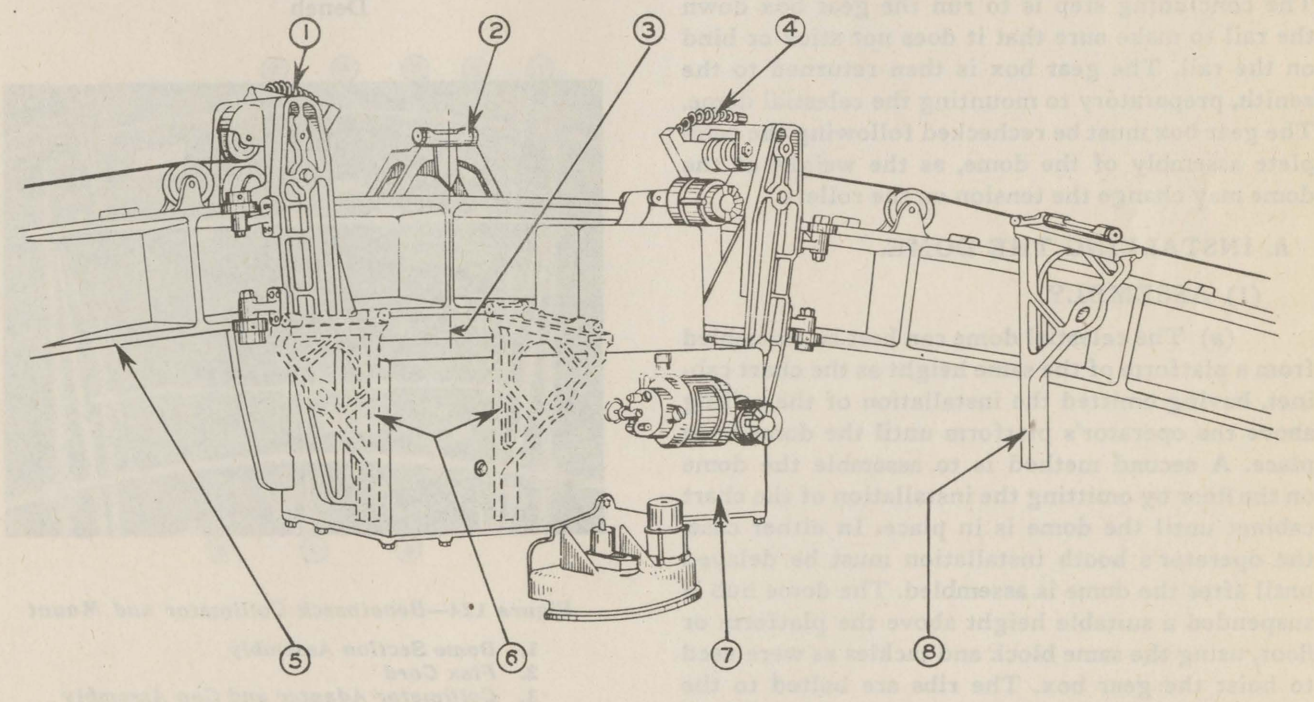

Figure 122—Leveling the Dome Rail and Gear Box

1. *Safety Pawl Spring*
2. *Zenith Level*
3. *Center Line of Main Shaft*
4. *Safety Pawl Spring*
5. *Dome Rail*
6. *Precision Level*
7. *Main Gear Box*
8. *Precision Level*

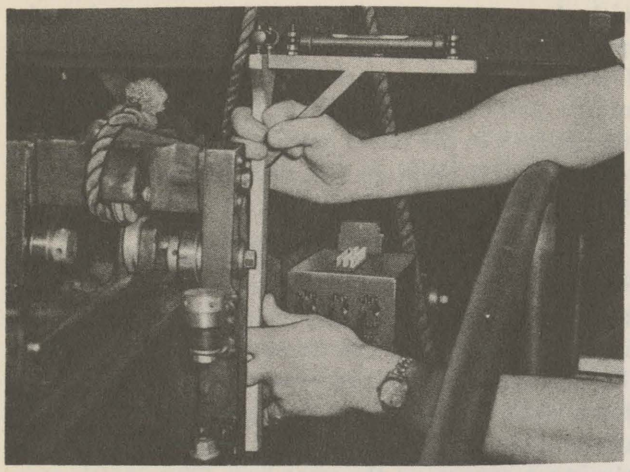

Figure 123—Leveling the Dome Gear Box

justing the roller cams by means of a 3/16-inch rod. Care must be taken that the cam lock nuts are drawn up snug before the level is checked, and it is necessary to hold the cam while tightening the nut. The gear box must be level within ± 30 seconds in both directions and all rollers must bear evenly against the rail. When this is accomplished, the bottom and side rollers should be adjusted so that they can just be turned by hand. The level is then rechecked. The concluding step is to run the gear box down the rail to make sure that it does not stick or bind on the rail. The gear box is then returned to the zenith, preparatory to mounting the celestial dome. The gear box must be rechecked following the complete assembly of the dome, as the weight of the dome may change the tension on the rollers.

h. INSTALLING THE DOME.

(1) ASSEMBLY.

(*a*) The celestial dome can best be assembled from a platform of the same height as the chart cabinet, having omitted the installation of the railing above the operator's platform until the dome is in place. A second method is to assemble the dome on the floor by omitting the installation of the chart cabinet until the dome is in place. In either case, the operator's booth installation must be delayed until after the dome is assembled. The dome hub is suspended a suitable height above the platform or floor, using the same block and tackles as were used to hoist the gear box. The ribs are bolted to the dome hub in their proper order, by reference to the rib number tags, and numbers stamped on the dome hub adjacent to the lower mounting pads. A varying number of spacing washers are furnished with each rib and, of these, one washer always is placed between the head of the mounting bolt and the inside of the hub. The remainder of the washers are placed between the rib and the outside of the hub. A 3/8- by 16-inch tap should be run into each rib and a suitable thread lube applied to each bolt. The hoops, omitting the outer bottom to facilitate mounting the dome, are next mounted and positioned by the tags referring to adjacent ribs and by the clamps and paint marks on the ribs and hoops. The joints in the hoops are fitted with a piece of rubber tubing and taped so as to completely fill the clamp.

(*b*) The collimators omitting Polaris, Regulus, and Altair, are now positioned on the proper ribs. Each collimator has a serial number which identifies the aperture or magnitude of the star; those carrying a 40,000 serial number have a .004-inch opening, 60,000 have a .006-inch opening and 80,000 have an .008-inch opening.

40,000	60,000	80,000
Alpheratz	Aldebaran	Capella
Polaris	Pollux	Arcturus
Dubhe	Regulus	Vega
Benesh	Altair	
	Deneb	

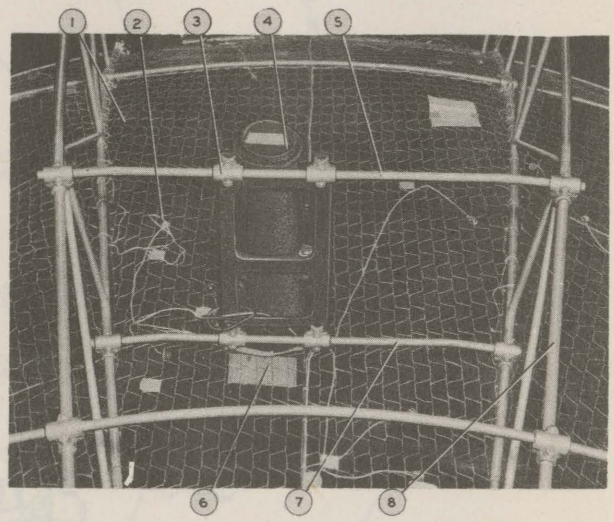

Figure 124—Benetnasch Collimator and Mount

1. *Dome Section Assembly*
2. *Flax Cord*
3. *Collimator Adapter and Cap Assembly*
4. *Collimator*
5. *Outer Ring Mounting Bracket*
6. *Collimator Identification Tag*
7. *Inner Ring Mounting Bracket*
8. *Dome Rib*

Benetnash is mounted on a special mounting between ribs No. 10 and No. 11 (figure 124).

(*c*) The wire mesh sections with the fixed star lamps and leads in place, are next laced to the dome, being careful to center the collimators in the cut-outs so that the position of the stars will agree with that of the collimators. The wire mesh is held by a flax cord lacing, using marlin hitches spaced two inches apart. It will be necessary to support the lower sections of mesh by wires run to the outside adjacent ribs.

(*d*) The need is stressed for thorough cross bracing of the dome ribs midway between the three pairs of hoops. This should be done carefully to maintain even tension (a soft iron wire bracing, crisscross fashion, is considered satisfactory).

(2) MOUNTING THE DOME.

(*a*) The dome is now ready to be hoisted into place. The gear box should be placed in neutral, if this has not been done previously. The dome is then hoisted carefully into place, rotating the gear box shaft as necessary to make the slip ring fall into the

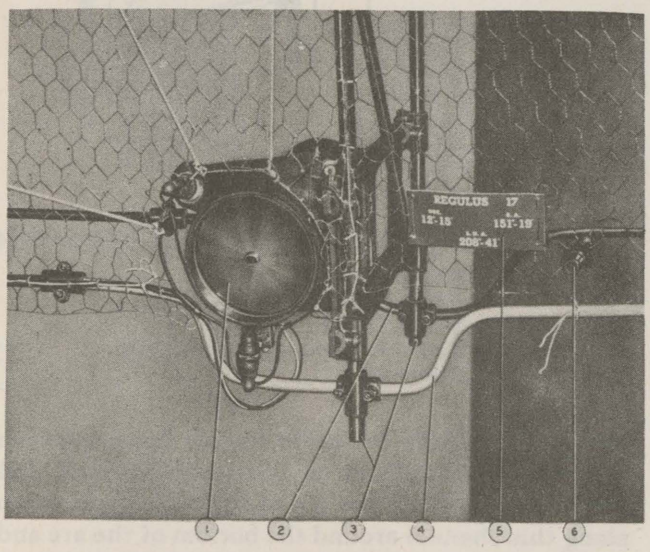

Figure 125—Regulus Collimator and Mount

1. ***Collimator Lens***
2. ***Outer Hoop***
3. ***Dome Rib***
4. ***Inner Hoop***
5. ***Identification Tag***
6. ***Star Lamp***

same relationship as disassembled. The block and tackles are now secured, holding the dome in place. The dome hub nut is installed from the transit platform or from a bosun's chair, depending on what method of adjusting the dome is to be used.

(*b*) The outer bottom ring is next installed and the Regulus and Altair collimators are mounted.

(*c*) Attach the slip ring assembly to the main shaft and adjust the brushes to ride the rings correctly when the brush block is mounted on the gear box.

(*d*) The leads from the slip rings to the transformers, and the leads from the stars and collimators to the busses, must be reconnected. The collimator terminal blocks are next wired according to the color coding.

(*e*) The LHA Aries take-off may be installed from the bridge with the help of an additional man standing on a stepladder on the transit platform, or from the top of the fuselage with the dome lowered. (See figure 4.) The split gear must be loaded from below by rotating the two halves of the gear with respect to each other against the spring tension. With the split gear loaded, the take-off is set in place so as to mesh the split gear and the hub ring gear, and is then bolted into place.

i. THE DOME COUNTERWEIGHT SYSTEM. (*See figure* 126.)

(1) A counterweight is installed to provide a restoring force to the dome which opposes the gravitational force tending to pull it down the rail. As the dome proceeds down the rail to lower latitudes, the effect of gravity increases according to the sine law, so that the restoring force must increase in a similar manner. This is accomplished by the use of a sector connected to the dome gear box by a cable and attached to the southwest column. The sector supports a counterweight on a radius which will travel through the same angular deflection as the dome, so that a balanced condition will exist for all positions of the dome in its travel along the rail.

(2) Two other weights are used in the system in addition to the one just discussed. The sector counterweight is mounted on top of the sector near its supporting shaft to balance the sector structure itself, and the dome return weight is suspended by a cable from the top outer section of the sector to provide an additional constant restoring force to the dome. Therefore, when the system is properly adjusted, the dome will always tend to return to the top of the rail.

(3) The sector should be placed on the southwest column and may be raised into position by two ropes suspended from the steel work above. The supporting bracket should be loosened so that the shaft can be inserted. The sector is then raised

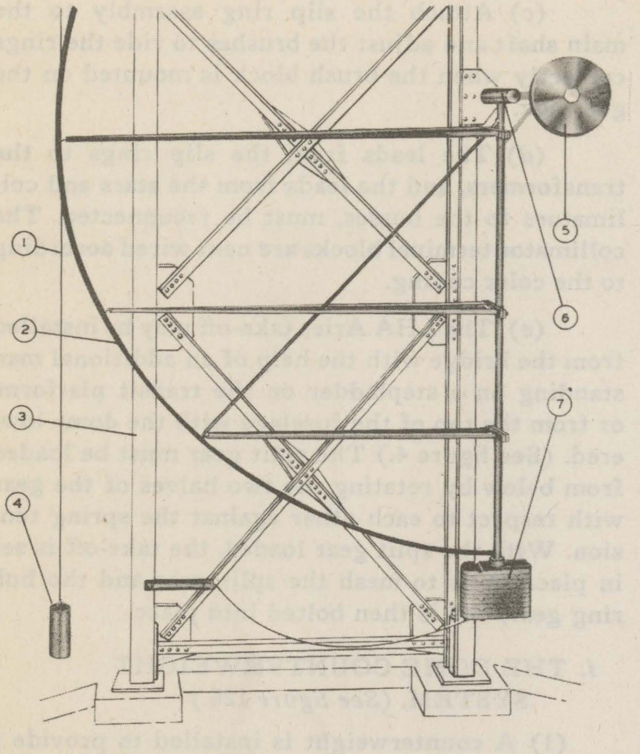

Figure 126—Dome Counterweight System

1. *Counterweight Sector Cable*
2. *Dome Counterweight Sector*
3. *South Column*
4. *Dome Returning Weight*
5. *Dome Sector Counterweight*
6. *Counterweight Sector Pivot Bearing*
7. *Main Counterweights*

into position, and the shaft fastened securely into the bracket. It will be necessary to support the sector at the east end until the sector counterweight has been installed, so that it will not swing down and hit the wall.

(4) The sector counterweight, which is the lighter of the two large weights, is raised into position and secured on its support near the shaft. When this weight is positioned correctly the sector, when hanging freely, will assume a position such that the mount for the main dome counterweight will be directly beneath the sector mounting shaft. The sector counterweight may be increased or decreased to satisfy this condition. The sector should then be checked to see that it turns freely without binding throughout the operating range.

(5) The main counterweight should be attached next to its support at the bottom of the sector. The cable between the sector and the gear box should now be installed. The end of the cable with the thimble is attached to the under side of the south safety pawl (figure 3) in such a manner that the tension on this cable will keep the pawl disengaged. There is a bolt which screws into this shaft and holds the thimble.

(6) The cable is led back to the double pulley attached by a bracket on the south wall which changes its direction so that it can be led to another

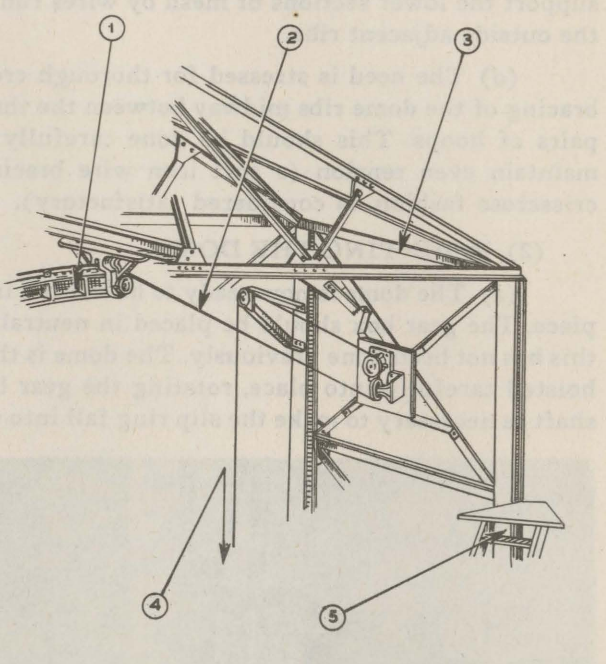

Figure 127—Counterweight Sector Cable Arrangement

1. *Dome Rail*
2. *Dome Counterweight Cable*
3. *South Tower*
4. *Cable to Dome Counterweight*
5. *Stairway*

pulley. From here the cable travels down between the two guide pulleys on the southeast wall and into the channel on the arc of the sector and down along this channel around the bottom of the arc and back to the clamp which is located on the inside of the channel. The cable should be drawn up so that with the gear box at the top of the rail, and the weights installed, there will not be any slack in the cable.

(7) A safety stop or hydraulic snubber is provided for the counterweight sector. This stop is bolted to the east upright of the south steel column. The stop is half filled with a medium weight oil, and at all times should be kept in such a position that the plunger is fully inserted in the shell. The

cable is attached to the sector below the main weight.

j. LATITUDE DRIVE AND RESET ASSEMBLY. (*See figure* 8.)—This assembly should now be installed on the north steel column. The cable connecting the north end of the gear box to the latitude drive is installed next. The thimble on this cable is attached in a similar manner to the north safety pawl and then run over the pulleys on the rail and over the pulley in the lower supporting fork, down to the drum on the latitude drive where it is fastened with the clamp provided. Approximately one turn of cable should be allowed on the drum before it starts to draw the dome down.

k. CHECK POINTS.

(1) The next step is to check the dome for static balance. To accomplish this, it is necessary to crank the dome to about 40 degrees latitude, and then with the reset clutch in neutral, turn the dome to various positions and see whether there is any indication of a heavy side. If this condition exists, a balancing weight should be attached to the bottom hoops on the opposite side of the dome, until the dome is balanced statically, and shows no tendency to move.

NOTE

The rail should be wiped clean before the gear box is run down.

(2) At this time it is well to see whether the gear box is free from excessive friction throughout its range of travel up and down the rail.

(3) If no excessive friction is found and there is no tendency for the rollers to bind, the main counterweight should be checked for correct loading. This can be done either by using a spring scale or by hand. Placing the dome at different latitudes, determine the force necessary to overcome the static friction and start the dome in motion in either direction. If the force to start the dome either up or down at any given latitude is the same, then it can be said the dome is perfectly balanced. This test should be repeated throughout the latitude range to see that the balance is satisfactory at all points. The friction drag of the gear box increases as it moves down the rail, so that in actual practice the main counterweight must be loaded so that it exerts a force slightly more than enough to balance the system. The loading of the weight should be such that the force to start the dome upward will be approximately the same at all latitudes and of a small magnitude of about six to eight pounds. This arrangement, of course, gives a varying force for downward movement for different latitudes, so that a check must be made to insure that there is not too great a drag on the latitude crank at low latitudes.

(4) When this has been completed, the third small weight of about twenty pounds is supported from a cable attached to the top of the sector arc and running in the channel so that it always applies its force from the point where the main cable joins the channel, or to an arm whose length is the radius of the sector, and in this way delivers a constant force throughout the operating range. With this weight installed, the dome should have a constant tendency to return to the zenith of the rail. This can best be checked by using the latitude hand crank and seeing whether the dome moves smoothly up and down the rail.

(5) In permitting the dome to return to the top of the rail it will be found necessary to unwind the latitude drive slowly enough to keep sufficient tension on the cable, thus keeping the north safety pawl disengaged. If either of the pawls will not remain disengaged when sufficient force is applied to move the dome easily, it will be necessary to adjust the springs tending to engage them. A force of a few pounds should be sufficient to effect disengagement. When the whole system is properly adjusted, the dome will move up and down smoothly and without too much effort, taking care not to force the dome down with the crank if it shows any tendency to stick, as this may damage the unit. It is recommended that the rail be carefully cleaned to prevent unnecessary restrictions before the dome is run down. Care should be taken that the cables do not chafe at any point, and thus become prematurely worn.

l. INSTALLING AND CONNECTING THE CONTROL DESK.

(1) The desk is so placed as to allow room for setting up the operator's booth around it. The 2-conductor armored cable, which comes from the building wall junction box through a floor conduit to the booth, should be wired into the desk junction box on terminals (1) and (2). The desk to dome cable (33-wire) is then plugged into the desk junction box to be ready for use in adjusting the dome collimators.

(2) The pulleys for the dome electrical supply are mounted, one on the north wall of the building

and one on the north truss tie rods, all in line with the cable dome gear box terminal block. The Jones plug to this terminal block is held in place by two U-clamps. The dome electrical supply cable (33-wire from the desk), the latitude drive cable and the clutch neutral indicator light cable are fastened to the building wall.

m. INSTALLING THE TRANSIT MOUNT AND FIXTURE. (*See figure* 128.)

(1) Lower the dome to a convenient latitude and place the Trainer on a south heading. In this position it is possible to stand on the fuselage and attach the transit mount to the dome hub. Be sure to turn the transit mount to a position to fit correctly over the Polaris mount. The four hook bolts provided can easily be placed to hold the transit mount securely. Slots are provided in the top ring of the transit mount to permit visual inspection of the fit of the transit mount to the dome hub. The mount must be flush to the dome hub. Next, fasten the color-coded cable ends to the corresponding buss bars on the dome hub. Move the dome manually back to the zenith mark with the latitude reset drive.

(2) Mount the transit by raising the four projections on the transit fixture through the cutaway portions of the ring on the lower end of the transit mount. Turn the transit fixture slightly and it will be supported by the ring. The clamps provided have both upper leveling and lower locking screws. When the transit has been leveled by the upper screws, it should be securely locked in place by tightening the lower screws on the clamps. Fasten the electrical connector on the end of the wire from the transit mount to the panel type connector on the transit.

NOTE

One division on the bubble scale of the small right angle levels on the transit fixture is equal to one minute of arc. Releveling the transit is not necessary as long as the error does not exceed the allowable error (± 1/2 minute).

n. ADJUSTMENT OF COLLIMATORS FOR DECLINATION AND SIDEREAL HOUR ANGLE USING TRANSIT MOUNT AND FIXTURE.

(1) GENERAL.—The collimators are mounted by three bolts to brackets which clamp on the dome ribs. (See figure 17.) The three bolts ride in arc shaped slots so that they may be lined up horizontally and vertically prior to any adjustment, and so as to permit free angular adjustment of the collimator. A typical collimator is illustrated. (See figure 125.) Only the two outer bolts are normally used for adjustment. The one in the horizontal plane is for sidereal hour angle adjustment and the one at the other end of the bracket, in the vertical plane, is for declination adjustment. The center bolt must be set originally so that its spring is under tension and at the approximate center of its range. A small amount of adjustment may be obtained by the use of this bolt, but only when the range of the outer two is insufficient.

NOTE

To change the altitude of a collimated star, probable adjustment to both bolts will be needed, particularly if the dome is not at the zenith, or if the LHA of the star is other than zero degrees or 180 degrees.

(2) LEVELING THE DOME.—Level the dome using the level mounted on the transit barrel. When the bubble is centered, swing the dome 180 degrees and check the position of the bubble. If the bubble indicates that the dome is not level, adjust the gear box rollers to remove half the error. Readjust the transit to level and return the dome to the original position. If the dome is not within one-minute total error, repeat the process. Next swing the dome to 90 degrees and 270 degrees and adjust as before. Now the dome should check within the allowable tolerance of ± 1/2 minute.

NOTE

One division on the transit barrel level is equal to 80 seconds of arc. If any doubt exists as to the accuracy of the transit, check results by using a sextant of known index error on a star of low declination. Remember that the transit mount and fixture can be used for adjusting the LHA Aries and the collimators when the dome is at the zenith only.

(3) POSITIONING THE FIRST POINT OF ARIES.

(*a*) With the transit at the center of the dome sphere, sight on the center line of the dome rail, with the transit bearing plate set at zero.

(*b*) Set the dome so that the Alpheratz collimator is on the lower branch of the meridian; adjust the collimator to bring the star on the hori-

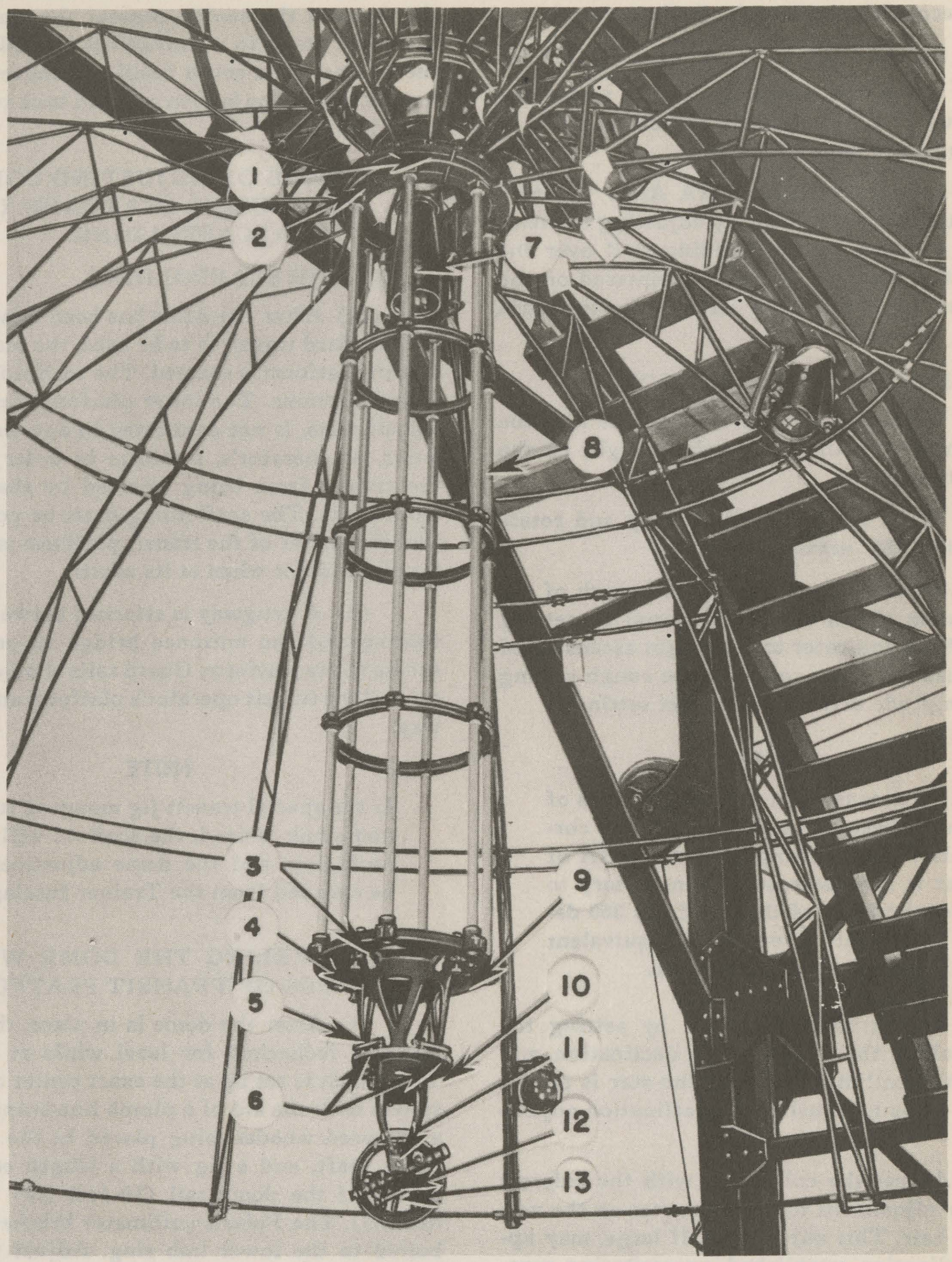

Figure 128—Transit Mount and Fixture

1. *Dome Hub*
2. *Upper Ring*
3. *Upper Leveling Screws*
4. *Lower Locking Screws*
5. *Transit Mount*
6. *Right Angle Levels*
7. *Polaris Collimator*
8. *Transit Fixture*
9. *Lower Ring*
10. *Azimuth Ring*
11. *Vertical Scale*
12. *Transit Barrel*
13. *Transit Barrel Level*

zontal and vertical cross hairs of the transit and near the recognition mirror in the lens center.

(*c*) Set the LHA Aries indicator to 181° 21′.

(*d*) Using the longitude drive, rotate the dome minus 1° 21′ (longitude switch on "W" so that the indicator shows 180° 00′).

(*e*) Attach the master LHA Aries "locator" projector to rib No. 11, focus by adjusting the lens, and place a target on the building wall over the bridge so that the spot of light is centered on the target cross when the LHA Aries indicator reads 180° 00′.

(4) ADJUSTING COLLIMATORS.

(*a*) With the dome at the zenith and the transit centered in the dome sphere, sight on the dome rail center line.

(*b*) Focus the transit on infinity and rotate it exactly to a 180° azimuth.

(*c*) Set the star on the upper branch of the local meridian (LHA star equals zero) by setting the LHA Aries indicator to read right ascension of the star (use the dome reset for the rough setting and the longitude drive for the exact setting).

NOTE

The right ascension of the star in terms of arc is used because in determining the correct LHA Aries setting when the LHA of the star is zero degrees, it is necessary to subtract the SHA of the star from 360 degrees. The result is, of course, equivalent to the right ascension of the star.

(*d*) Adjust for declination by setting the vertical scale of the transit to the declination, and adjusting the collimator so that the star is on the horizontal cross hair, using the declination adjustment.

(*e*) Adjust the collimator with the sidereal hour angle adjustment to place the star on the vertical cross hair. This adjustment, if large, may upset the declination established, necessitating repetition of step (*d*).

(*f*) Check that the star appears very near the recognition mirror mounted in the center of the collimator lens.

(*g*) Repeat the foregoing procedure with each collimated star.

(*h*) With the collimators adjusted, and with the dome at the zenith, remove the transit. Crank the dome down to a convenient altitude, and with the Trainer on a south heading remove the transit fixture. The dome is then cranked back to the zenith mark by hand.

o. METHOD OF ADJUSTING COLLIMATORS, USING STANDARD TRANSIT AND SCAFFOLDING.

(1) THE SCAFFOLDING.

(*a*) After the dome has been raised in place, if a standard transit is to be used, the scaffolding or transit platform is erected. The scaffolding is made in two sections. The inner platform, on which the transit rests, is not connected in any way with the outer, or operator's, platform in order to prevent the transit from being affected by the operator's movements. The scaffolding must be positioned so that the center of the transit platform is at the center of the dome when at its zenith.

(*b*) A gangway is attached between the scaffolding and the entrance bridge to provide easy access to the platform. Guard rails should be erected around the transit operator's platform and the gangway.

NOTE

If the special transit jig mounted from the dome hub is used, the scaffold will be unnecessary, and the dome adjustment will be checked from the Trainer fuselage.

(2) LEVELING THE DOME WITH THE USE OF TRANSIT PLATFORM.

(*a*) After the dome is in place, the gear box must be rechecked for level while at the zenith. The transit is set up at the exact center of the dome sphere with the aid of a plumb line suspended from a centered wooden plug placed in the end of the dome shaft, and a jig with a length equal to the radius of the dome rail (10 feet 8.64 inches, figure 129). The Polaris collimator bracket should be bolted to the lower hub ring. Adjust the Polaris plumb bob jig at its lower end so that the plumb line hangs clear within the jig when the dome is at the zenith.

(*b*) Still at the zenith, the dome must be leveled by sighting on a star of low declination and checking the altitude at 0°-90°-180°-270° LHA of the star. An increase in the altitude in one direc-

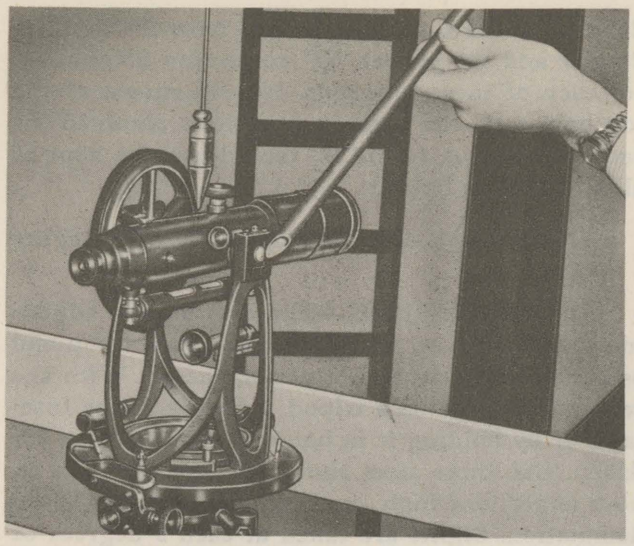

Figure 129—Centering Transit with Jig

tion indicates that the dome is too high in that direction. In this event, the dome must be leveled by means of the gear box rollers in the same manner as used in the original leveling.

NOTE

A later dome level check at various latitudes follows establishment of the latitude setting correction factor.

(*c*) Adjust the collimators as in previous method.

NOTE

If the transit platform is used it will be necessary to hook up a temporary "collimator-recognition" switch. One lead of this switch may be connected to No. 3 terminal in the desk junction box, and the other lead to the left side winding of the collimator-recognition "on" relay (second relay from left in the desk junction box). This switch, when closed, will turn on the recognition star lamps and the Aries projector.

p. ALTERNATE SEXTANT METHOD FOR ADJUSTING THE COLLIMATORS. — If the dome is to be adjusted without a transit, the need for the transit platform is eliminated. It will be necessary to install the dome nut from a bosun's chair suspended from the arch above the gear box. After the dome is mounted, the base and fuselage must be installed and put in operating condition. The dome will be adjusted using a sextant and two plumb lines. One plumb line is suspended as before from the center of the dome hub, and the second from an especially designed clamp attached on the dome rail center line.

(1) LEVELING THE DOME (SEXTANT METHOD).

(*a*) Clamp the sextant to a tripod mounted in the fuselage at the center of the dome sphere, found by use of the plumb line from the dome shaft center (dome at zenith), and the jig whose length is equal to the dome rail radius.

(*b*) Sight on a star of medium declination and check the altitude at 0°-90°-180°-270° LHA of the star.

(*c*) Level the dome as in the previous method.

(2) ADJUSTING COLLIMATORS (SEXTANT METHOD).

(*a*) With the dome at the zenith and the sextant centered in the dome sphere, bring Alpheratz beneath the dome rail. Suspend a plumb line, using the special clamp, from the center line of the dome rail 4 inches to 6 inches in front of the Alpheratz collimator. Care must be taken that the plumb line does not touch the dome.

(*b*) Adjust for declination by setting the sextant to 28° 47′ (declination of Alpheratz) and setting the collimator to that altitude by means of the declination adjustment, checking that the star is near the lens center.

(*c*) Adjust for sidereal hour angle by sighting across the two plumb lines, with the eye as far as possible from the center plumb line. The star should appear to touch both lines and be approximately in the center of the lens. If a major sidereal hour angle adjustment is made, recheck the declination.

(*d*) Adjust all collimators for declination and sidereal hour angle with the dome at the zenith, similarly to Alpheratz, using the sextant and plumb lines. When the collimators are adjusted, check the dome droop and make out calibration sheets on Forms "A" and "B," using the sextant in place of the transit. (See section IV, par. 3*s*.)

q. ALTERNATE SEXTANT METHOD FOR POSITIONING THE FIRST POINT OF ARIES.

(1) After adjusting Alpheratz for sidereal hour angle by the use of two plumb lines as de-

scribed previously, set the LHA Aries indicator to read 181° 21′.

(2) Proceed to adjust the LHA Aries "locator" projector as described in the transit method.

NOTE

If the transit platform is used it will be necessary to hook up a temporary "collimator-recognition" switch. One lead of this switch may be connected to No. 3 terminal in the desk junction box, and the other lead to the left side winding of the collimator-recognition "on" relay (second relay from left in the desk junction box). This switch, when closed, will turn on the recognition star lamps and the Aries projector.

r. POLARIS COLLIMATOR. (*See figure* 130.)

(1) Polaris is mounted on the dome hub. If the transit platform is not used, Polaris can be installed from the top of the fuselage, with the Trainer on

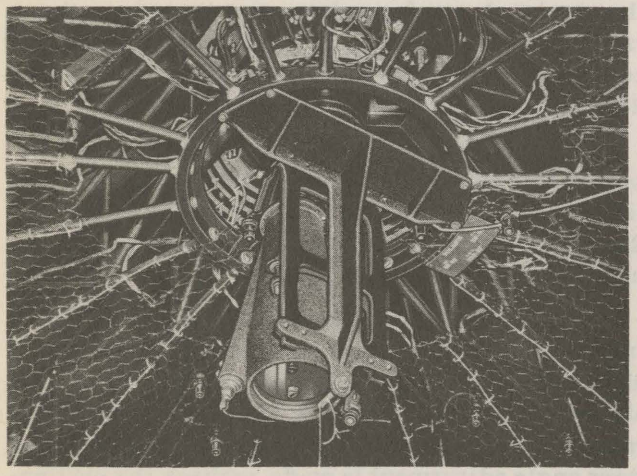

Figure 130—Polaris Mount

a south heading and the dome at a suitably low latitude. The proper latitude correction factor for this dome setting should be applied in setting the latitude indicator before moving the dome down the rail. (See section IV, par. 3*s*.)

(2) The method of Polaris collimator adjustment is to determine the correct altitude by applying the Polaris "Q" correction, with the signs reversed, from the Air Almanac for several values of LHA of Aries with the dome at any convenient latitude. The three-collimator adjustment bolts are successively brought to top position by rotating the dome. The LHA of Aries is read from the desk indicator and the proper "Q" correction determined for each of these positions. By adjustment of the top bolt only, the correct altitude is obtained for each position. A form "B" record is to be kept of all altitudes of Polaris.

s. COMPILATION OF FORM "A." (*See figure* 131.)

(1) PROCEDURE.—The next step in adjusting the dome is to determine the mean droop and establish the latitude correction factor. With the sextant mounted on a tripod, a fixture in the fuselage, or by holding it in hand, check the dome for droop. Use three stars about 120 degrees apart in hour angle; one high, one low, and one of medium declination. Sights are taken at each 5 degrees of latitude on the upper and lower branch of the local meridian where visible. The variation between the observed altitude and the calculated altitude at each 5 degrees of latitude is the amount of dome droop (negative on the upper branch and positive on the lower branch). The mean error between the three observed stars at each latitude is used in making up a table or latitude correction card giving the latitude setting correction. A record of the observed altitudes is made on Form "A."

(2) LATITUDE CORRECTION CARD.

(*a*) The dome has a tendency to droop at the lower latitudes. The reason for this is obvious. Any structure supported only at one end has a tendency to bend or droop. To compensate for this, a latitude correction card is made out during the original installation, so that reasonable accuracy can be expected during a problem.

(*b*) To simplify and further explain the latitude correction card, a specific example is given:

1. It is desired to check the dome droop at latitude 60 degrees. With the dome at the zenith (against the stops), refer to the latitude correction card and note the error at 60 degrees latitude. Let us assume it is + 6 minutes.

2. Set latitude indicator to 90° 06′.

3. Crank the dome down until the latitude indicator reads 60° 00′.

4. The dome, if it were not for droop, would actually now be 59° 54′. However, since the dome droops 6 minutes at 60 degrees latitude, the 6-minute error cancels out, and for celestial problems the dome is at 60° 00′ N latitude.

MEAN DOME DROOP LHA STAR 0° or 180°

Stars	Dubhe Upper Br.			Dubhe Lower Br.			Regulus Upper Br.			Pollux Upper Br.		
Lat.	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
35°	62°56'			7°04'			67°15'			83°10'		
40	67 56			12 04			62 15			78 10		
45	72 56			17 04			57 15			73 10		
50	77 56			22 04			52 15			68 10		
55	82 56			27 04			47 15			63 10		
60	87 56			32 04			42 15			58 10		
65	87 04			37 04			37 15			53 10		
70	82 04			42 04			32 15			48 10		
75	77 04			47 04			27 15			43 10		
80	72 04			52 04			22 15			38 10		
85	67 04			57 04			17 15			33 10		
90	62 04			62 04			12 15			28 10		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Sample Calculation:

Lat. 35°   Hc = 62°56'   Ho = 63°09'   E = + 13'

Average of Errors for any one Latitude is equal to "Setting Latitude Correction."

Figure 131—Computed Altitudes, Form A

5. Referring to Form "A," sight on the collimated stars at 60 degrees and compare Hc (calculated altitude) with Ho (observed altitude). The allowable tolerance is ± 5 minutes.

(3) CHECKING THE DOME LEVEL AT LOWER LATITUDES.—With the latitude setting correction applied, according to the correction card, check the altitude of a star of medium declination for 60 degrees and 300 degrees LHA star at latitudes 35°-40°-45°-50°-75° N. This indicates whether the dome remains level and undistorted at lower latitudes prior to the complete check of the stars.

t. COMPILATION OF FORM "B." (*See figure* 132.)—Observe the altitudes of all the stars at the latitude where greatest accuracy is required (45 degrees N). The maximum allowable error is ± 5 minutes, which may necessitate a change in the sidereal hour angle adjustment to bring the altitude within this limit. Then observe the altitudes of all the stars for each 30 degrees LHA Aries and at latitudes 35°-40°-45°-50°-75° N, wherever the altitude (upper and lower branch) is greater than 10 degrees. The suggested order is to set the latitude and the LHA Aries, and check all the stars; then change the LHA Aries 30 degrees, and check all the stars, repeating until all twelve of the LHA Aries settings are complete; then change the latitude and repeat. A careful record of observations is kept on Form "B" which contains the calculated altitude for each LHA Aries at the latitudes to be checked.

4. INSTALLING THE BASE COUNTERBALANCE FRAME, TOWER AND FUSELAGE.

a. INSTALLING THE TRAINER BASE.

(1) Mark the center of the dome on the building floor by means of a plumb line from the center of the dome shaft (dome at zenith).

(2) Set up the transit over the center and with the bearing plate set at zero, sight on the center line of the dome rail. Lay out a north-south line and an east-west line on the floor.

(3) Center the main bearing beneath the center of the dome using the plumb line and a disc inserted in the slip ring housing (tolerance ± 1/16 inch).

(4) Align the center punch mark on the west leg with the east-west line on the floor and approximately level the bearing (tolerance ± 1/16 inch).

(5) Mark the center of the hold-down bolt holes.

(6) Shift the base and drill holes in the floor for the expansion plugs (3/4-inch expansion plug, drill 1-1/8 inches and insert the plugs).

(7) Re-align the base and adjust the leveling screws so that the top of the main bearing hub is level, by reference to a spirit level across the hub, and so that it is 30 feet 2 inches (± 1/2 inch) from the bottom of the dome rail at the zenith.

(8) Set up the hold-down bolts and recheck the alignment.

(9) Install the tower on the carriage.

b. ALIGNMENT OF THE TOWER.

(1) Set up the mounting bolts on all three legs.

(2) Suspend a plumb line from the center of one fuselage mounting pad. This line must be 48 inches from the center of rotation and on the center line of the carriage.

(3) Align the tower by taking up on the tie rods. Lock all tie rods.

c. MOUNTING THE FUSELAGE.

(1) Install the base counterweights on the carriage and fasten the locking bolt. (See figure 58.)

(2) Lower the dome to as low a latitude as possible and put the dome in neutral.

(3) Mount two 1-ton block and tackles, one on the east arch where the south diagonal brace is attached, and one on two 2- by 10-feet planks, on the east side of the dome rail. For the second block and tackle it will be necessary to use a 10-foot chain suspended through the dome (figure 133).

(4) The block and tackle beside the dome rail is hooked directly to the lifting eye in front of the navigator's station. The block and tackle from the arch is hooked to a chain on the two rear lifting eyes.

(5) Attach three or four guide ropes to the bottom corners of the fuselage.

(6) Hoist the fuselage and rotate the tower into position, then lower the fuselage onto the mounting pad, after inserting the four jack cables and the fuselage lock cable into the mounting tube (figure 134).

(7) Bolt the fuselage universal joint to the tower and install safety cables.

LATITUDE 35°N

STARS	ALPHERATZ			POLARIS			ALDEBARAN			CAPELLA		
	Dec.		SHA	Dec.		SHA	Dec.		SHA	Dec.		SHA
	28°47'N		358°38'	88°59'N		333°52'	16°24'N		291°50'	45°56'N		281°53'
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°	83°40'			35°54'			27°01'			31°58'		
30	65 00			36 00			51 15			52 25		
60	40 32			35 50			70 01			72 29		
90	17 03			35 26			63 03			75 51		
120				34 55			40 21			56 45		
150				34 26			15 53			36 06		
180				34 06						17 09		
210				34 00								
240				34 10								
270	15 01			34 33								
300	38 20			35 03								
330	62 46			35 33						13 36		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 1 of 30 pages)

LATITUDE 35°N

STARS	POLLUX			REGULUS			DUBHE			BENESH		
	Dec.		SHA	Dec.		SHA	Dec.		SHA	Dec.		SHA
	28°10'N		244°33'	12°15'N		208°40'	62°04'N		194°57'	49°36'N		153°40'
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°							07°49'					
30	19°10'						13 36					
60	42 52			05°57'			24 01					
90	67 21			30 23			37 17			11°37'		
120	82 09			53 39			51 04			28 05		
150	59 56			67 13			61 19			46 59		
180	35 32			55 30			61 21			65 52		
210	12 20			32 33			51 07			75 10		
240				08 04			37 20			61 29		
270							24 04			42 15		
300							13 38			23 45		
330							07 50			07 11		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

***Figure 132—Computed Altitudes, Form B** (Page 2 of 30 pages)*

LATITUDE 35°N

STARS	ARCTURUS			VEGA			ALTAIR			DENEB		
	Dec.	SHA		Dec.	SHA		Dec.	SHA		Dec.	SHA	
	19°29'N	146°44'		38°44'N	81°14'		8°43'N	62°59'		45°05'N	50°07'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°				27°09'			27°03'			50°59'		
30				13 33						30 22		
60										11 58		
90												
120	08°45'											
150	32 36											
180	56 50			15 10								
210	74 13			36 11			7 25			17 52		
240	61 46			59 00			31 51			37 14		
270	37 57			82 04			53 56			58 13		
300	13 37			72 39			63 35			77 25		
330				49 23			50 00			71 40		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 3 of 30 pages)

LATITUDE 40°N

STARS	ALPHERATZ			POLARIS			ALDEBARAN			CAPELLA		
	Dec.		SHA	Dec.		SHA	Dec.		SHA	Dec.		SHA
	28°47'N		358°38'	88°59'N		333°52'	16°24'N		291°50'	45°56'N		281°53'
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°	78°43'			40°54'			27°03'			34°52'		
30	64 00			41 00			49 24			54 50		
60	41 13			40 50			65 21			75 31		
90	19 00			40 26			59 44			79 30		
120				39 55			39 28			59 09		
150				39 26			16 37			38 52		
180				39 06						20 37		
210				39 00						06 06		
240				39 10								
270	17 04			39 33								
300	39 09			40 03								
330	61 59			40 33						17 14		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 4 of 30 pages)

LATITUDE 40°N

STARS	POLLUX			REGULUS			DUBHE			BENESH		
	Dec.	SHA		Dec.	SHA		Dec.	SHA		Dec.	SHA	
	28°10'N	244°33'		12°15'N	208°40'		62°04'N	194°57'		49°36'N	153°40'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°							12°47'					
30	20°55'						18 18					
60	43 21			06°50'			28 21					
90	65 57			29 42			41 20			15°37'		
120	77 36			50 53			55 14			31 25		
150	59 17			62 13			66 08			49 53		
180	36 25			52 30			66 09			69 09		
210	14 28			31 43			55 16			80 04		
240				08 51			41 23			64 31		
270							28 23			45 13		
300							18 19			27 15		
330							12 47			12 22		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 5 of 30 pages)

LATITUDE 40°N

STARS	ARCTURUS			VEGA			ALTAIR			DENEB		
	Dec.	SHA		Dec.	SHA		Dec.	SHA		Dec.	SHA	
	19°29'N	146°44'		38°44'N	81°14'		8°43'N	62°59'		45°05'N	50°07'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°				29°33'			26°12'			53°19'		
30				10 42						33 14		
60										15 37		
90												
120	09°59'											
150	32 38											
180	54 54			18 08						06 13		
210	69 17			38 13			07 52			21 15		
240	59 15			60 14			30 38			39 53		
270	37 38			83 07			50 32			60 29		
300	14 48			73 35			58 36			81 08		
330				50 56			47 06			74 23		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 6 of 30 pages)

LATITUDE 45°N

STARS	ALPHERATZ			POLARIS			ALDEBARAN			CAPELLA		
	Dec.	SHA		Dec.	SHA		Dec.	SHA		Dec.	SHA	
	28°47'N	358°38'		88°59'N	333°52'		16°24'N	291°50'		45°56'N	281°53'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°	73°45'			45°54'			26°52'			37°32'		
30	62 11			46 00			47 08			56 46		
60	41 32			45 50			60 35			77 18		
90	20 49			45 26			56 02			81 37		
120				44 55			38 14			60 57		
150				44 26			17 13			41 23		
180				44 06						23 58		
210				44 00						20 48		
240				44 10								
270	19 00			44 33								
300	39 36			44 03								
330	60 25			44 33								

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 7 of 30 pages)

LATITUDE 45°N

STARS	POLLUX			REGULUS			DUBHE			BENESH		
	Dec.	SHA		Dec.	SHA		Dec.	SHA		Dec.	SHA	
	28°10'N	244°33'		12°15'N	208°40'		62°04'N	194°57'		49°36'N	153°40'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°							17°44'					
30	22°32'						22 58			07°20'		
60	43 25			07°42'			32 36			09 02		
90	63 43			28 47			45 15			19 35		
120	73 48			47 45			59 11			34 36		
150	57 54			57 14			70 50			52 25		
180	36 59			49 09			70 52			71 40		
210	16 31			30 37			59 13			84 47		
240				09 34			45 18			66 55		
270							32 38			47 53		
300							23 00			30 37		
330							17 45			16 31		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 8 of 30 pages)

LATITUDE 45°N

STARS	ARCTURUS			VEGA			ALTAIR			DENEB		
	Dec.		SHA	Dec.		SHA	Dec.		SHA	Dec.		SHA
	19°29'N		146°44'	38°44'N		81°14'	8°43'N		62°59'	45°05'N		50°07'
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°				31°46'			25°08'			55°10'		
30				14 03						35 54		
60										19 13		
90										06 45		
120	11°25'											
150	32 23											
180	52 29			21 00						10 24		
210	64 20			39 57			08 15			24 31		
240	56 14			60 45			29 11			42 15		
270	36 59			80 58			46 52			62 07		
300	15 53			73 03			53 38			83 01		
330				51 59			43 54			75 49		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 9 of 30 pages)

LATITUDE 50°N

STARS	ALPHERATZ			POLARIS			ALDEBARAN			CAPELLA		
	Dec.	SHA		Dec.	SHA		Dec.	SHA		Dec.	SHA	
	28°47'N	358°38'		88°59'N	333°52'		16°24'N	291°50'		45°56'N	281°53'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°	68°45'			50°54'			26°28'			39°59'		
30	59 42			51 00			44 31			58 06		
60	41 28			50 50			55 45			77 15		
90	22 29			50 26			52 04			81 05		
120	05 40			49 55			36 41			62 02		
150				49 26			17 42			43 35		
180				49 06						27 17		
210				49 00						14 36		
240				49 10						07 13		
270	20 49			49 27						06 29		
300	39 41			50 03						12 34		
330	58 12			50 33			07 24			24 18		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 10 of 30 pages)

LATITUDE 50°N

STARS	POLLUX			REGULUS			DUBHE			BENESH		
	Dec.	SHA		Dec.	SHA		Dec.	SHA		Dec.	SHA	
	28°10'N	244°33'		12°15'N	208°40'		62°04'N	194°57'		49°36'N	153°40'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°	06°47'						22°42'			12°07'		
30	23 59						27 38			09 39		
60	43 05			08°30'			36 46			13 41		
90	60 51			27 38			48 59			23 29		
120	67 54			44 21			62 49			37 36		
150	55 56			52 14			75 22			54 31		
180	37 14			45 32			75 24			73 05		
210	18 28			29 17			62 52			87 36		
240				10 12			49 01			68 27		
270							36 48			50 11		
300							27 39			33 50		
330							22 42			20 38		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 11 of 30 pages)

LATITUDE 50°N

STARS	ARCTURUS			VEGA			ALTAIR			DENEB		
	Dec.	SHA		Dec.	SHA		Dec.	SHA		Dec.	SHA	
	19°29'N	146°44'		38°44'N	81°14'		8°43'N	62°59'		45°05'N	50°07'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°				33°46'			23°52'			56°28'		
30				17 19						38 21		
60										22 44		
90										11 12		
120	12°46'									05 28		
150	31 52			09 31						06 41		
180	49 39			23 46						14 34		
210	59 22			41 22			8 35			27 41		
240	52 49			60 30			27 31			44 19		
270	36 01			77 08			43 01			62 58		
300	16 52			71 13			48 39			81 44		
330				52 30			40 28			75 37		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 12 of 30 pages)

LATITUDE 55°N

STARS	ALPHERATZ			POLARIS			ALDEBARAN			CAPELLA		
	Dec.	SHA		Dec.	SHA		Dec.	SHA		Dec.	SHA	
	28°47'N	358°38'		88°59'N	333°52'		16°24'N	291°50'		45°56'N	281°53'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°	63°46'			55°54'			25°51'			42°07'		
30	56 41			56 00			41 36			58 45		
60	41 00			55 50			50 53			75 24		
90	23 59			55 26			47 54			78 14		
120	08 50			54 55			34 51			62 20		
150				54 26			18 02			45 27		
180				54 06						30 26		
210				54 00						18 48		
240	07 38			54 10						12 05		
270	22 29			54 33						11 26		
300	39 27			55 03						16 57		
330	55 26			55 33			08 49			27 41		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

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Figure 132—Computed Altitudes, Form B (Page 13 of 30 pages)

LATITUDE 55°N

STARS	POLLUX			REGULUS			DUBHE			BENESH		
	Dec. 28°10'N	SHA 244°33'		Dec. 12°15'N	SHA 208°40'		Dec. 62°04'N	SHA 194°57'		Dec. 49°36'N	SHA 153°40'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°	09°45'						27°39'			16°54'		
30	25 16						32 15			14 39		
60	42 20			09°15'			40 50			18 20		
90	57 29			26 17			52 28			27 19		
120	62 58			40 44			66 00			40 22		
150	53 26			47 14			79 29			56 05		
180	37 09			41 44			79 31			73 08		
210	20 17			27 44			66 03			84 10		
240	05 44			10 46			52 31			68 56		
270							40 52			52 04		
300							32 16			36 52		
330							27 40			24 42		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 14 of 30 pages)

LATITUDE 55°N

STARS	ARCTURUS			VEGA			ALTAIR			DENEB		
	Dec.	SHA		Dec.	SHA		Dec.	SHA		Dec.	SHA	
	19°29'N	146°44'		38°44'N	81°14'		8°43'N	62°59'		45°05'N	50°07'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°				35°30'			22°26'			57°07'		
30				20 31			05 26			40 31		
60				09 25						26 09		
90										15 37		
120	14°02'			05 29						10 26		
150	31 06			13 26						11 32		
180	46 30			26 23						18 41		
210	54 24			42 25			08 50			30 42		
240	49 08			59 28			25 39			46 00		
270	34 44			72 42			39 00			62 59		
300	17 42			16 22			43 39			78 15		
330				52 26			36 51			73 49		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 15 of 30 pages)

LATITUDE 60°N

STARS	ALPHERATZ			POLARIS			ALDEBARAN			CAPELLA		
	Dec.	SHA		Dec.	SHA		Dec.	SHA		Dec.	SHA	
	28°47'N	358°38'		88°59'N	333°52'		16°24'N	291°50'		45°56'N	281°53'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°	58°46'			60°54'			25°01'			43°56'		
30	53 17			61 00			38 26			58 42		
60	40 10			60 50			46 00			72 19		
90	25 18			60 26			43 37			74 17		
120	11 57			59 55			32 45			61 47		
150				59 26			18 13			46 55		
180				59 06						33 25		
210				59 00						22 58		
240	10 53			59 10						16 58		
270	23 59			59 33						16 23		
300	38 50			60 03						21 18		
330	52 17			60 33			10 10			30 56		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 16 of 30 pages)

LATITUDE 60°N

STARS	POLLUX			REGULUS			DUBHE			BENESH		
	Dec.		SHA	Dec.		SHA	Dec.		SHA	Dec.		SHA
	28°10'N		244°33'	12°15'N		208°40'	62°04'N		194°57'	49°36'N		153°40'
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°	12°40'						32°36'			21°39'		
30	26 21						36 50			19 39		
60	41 12			09°56'			44 46			22 57		
90	53 47			24 43			55 39			31 03		
120	58 01			36 57			68 33			42 52		
150	50 31			42 14			82 27			57 03		
180	36 45			37 44			82 29			71 48		
210	21 57			25 58			68 35			79 24		
240	09 08			11 15			55 41			68 19		
270							44 48			53 27		
300							36 51			39 42		
330							32 37			28 40		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 17 of 30 pages)

LATITUDE 60°N

STARS	ARCTURUS			VEGA			ALTAIR			DENEB		
	Dec.		SHA	Dec.		SHA	Dec.		SHA	Dec.		SHA
	19°29'N		146°44'	38°44'N		81°14'	8°43'N		62°59'	45°05'N		50°07'
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°				36°58'			20°50'			57°06'		
30				23 37			06 03			42 22		
60				13 45						29 28		
90				09 00						20 01		
120	15°11'			10 16						15 24		
150	30 03			17 19						16 22		
180	43 04			28 51						22 46		
210	49 25			43 05			09 02			33 33		
240	45 13			57 47			23 36			47 17		
270	33 11			68 02			34 51			62 09		
300	18 24			64 53			38 40			73 58		
330				51 49			33 05			70 52		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 18 of 30 pages)

LATITUDE 65°N

STARS	ALPHERATZ			POLARIS			ALDEBARAN			CAPELLA		
	Dec.	SHA		Dec.	SHA		Dec.	SHA		Dec.	SHA	
	28°47'N	358°38'		88°59'N	333°52'		16°24'N	291°50'		45°56'N	281°53'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0	53°46'			65°54'			24°00'			45°23'		
30	49 35			66 00			35 04			57 56		
60	39 00			65 50			41 05			68 31		
90	26 26			65 26			39 13			69 52		
120	15 00			64 55			30 26			60 28		
150				64 26			18 16			47 57		
180				64 06						36 12		
210				64 00						27 04		
240	14 06			64 10						21 50		
270	25 19			64 33						21 19		
300	37 52			65 03						25 37		
330	48 49			65 33						34 03		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 19 of 30 pages)

LATITUDE 65°N

STARS	POLLUX			REGULUS			DUBHE			BENESH		
	Dec.		SHA	Dec.		SHA	Dec.		SHA	Dec.		SHA
	28°10'N		244°33'	12°15'N		208°40'	62°04'N		194°57'	49°36'N		153°40'
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°	15°32'						37°33'			26°24'		
30	27 13						41 21			24 38		
60	39 43			10°32'			48 32			27 32		
90	49 50			22 59			58 24			34 40		
120	53 03			33 02			70 09			45 03		
150	47 17			37 15			82 42			57 21		
180	36 01			33 41			82 45			69 21		
210	23 28			24 01			70 11			74 29		
240	12 30			11 39			58 27			66 36		
270	05 15						48 34			54 16		
300	41 22						41 22			42 16		
330	07 08						37 33			32 34		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 20 of 30 pages)

LATITUDE 65°N

STARS	ARCTURUS			VEGA			ALTAIR			DENEB		
	Dec.	SHA		Dec.	SHA		Dec.	SHA		Dec.	SHA	
	19°29'N	146°44'		38°44'N	81°14'		8°43'N	62°59'		45°05'N	50°07'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°				38°07'			19°06'			56°25'		
30				26 36						43 52		
60				18 04						32 38		
90				13 58						24 23		
120	16°14'			15 04						20 21		
150	28 47			21 09						21 12		
180	39 27			31 07						26 46		
210	44 26			43 21						36 12		
240	41 09			55 30			21 24			48 07		
270	31 23			63 15			30 38			60 33		
300	18 58			60 58			33 41			69 21		
330	07 04			50 40			29 12			67 13		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 21 of 30 pages)

LATITUDE 70°N

STARS	ALPHERATZ			POLARIS			ALDEBARAN			CAPELLA		
	Dec. 28°47'N	SHA 358°38'		Dec. 88°59'N	SHA 333°52'		Dec. 16°24'N	SHA 291°50'		Dec. 45°56'N	SHA 281°53'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°	48°47'			70°54'			22°47'			46°24'		
30	45 41			71 00			31 33			56 31		
60	37 29			70 50			36 10			64 20		
90	27 22			70 26			34 45			65 14		
120	17 59			69 55			27 55			58 28		
150	11 20			69 26			18 11			48 31		
180	8 47			69 06						38 46		
210	10 55			69 00						31 05		
240	17 15			69 10						26 41		
270	26 27			69 33						26 16		
300	36 35			70 03						29 53		
330	45 06			70 33			12 38			36 58		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 22 of 30 pages)

LATITUDE 70°N

STARS	POLLUX			REGULUS			DUBHE			BENESH		
	Dec.	SHA		Dec.	SHA		Dec.	SHA		Dec.	SHA	
	28°10'N	244°33'		12°15'N	208°40'		62°04'N	194°57'		49°36'N	153°40'	
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°	18°18'						42°29'			31°08'		
30	27 52						45 48			29 38		
60	37 55			11°03'			52 03			32 05		
90	45 43			21 05			60 38			38 06		
120	48 05			29 00			70 38			46 52		
150	43 47			32 15			80 03			57 02		
180	34 58			29 31			80 04			66 06		
210	24 48			21 55			70 40			69 32		
240	15 49			11 57			60 40			64 10		
270							52 05			54 29		
300							45 49			44 33		
330	11 16						42 30			36 21		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 23 of 30 pages)

LATITUDE 70°

STARS	ARCTURUS			VEGA			ALTAIR			DENEB		
	Dec.		SHA	Dec.		SHA	Dec.		SHA	Dec.		SHA
	19°29'N		146°44'	38°44'N		81°14'	8°43'N		62°59'	45°05'N		50°07'
LHA ARIES	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E	Hc	Ho	E
0°				38°57'			17°13'			55°07'		
30				29 26						44 59		
60				22 20						35 37		
90				18 55						28 42		
120	17°10'			19 50						25 19		
150	27 17			24 53						26 01		
180	35 40			33 11						30 42		
210	39 27			43 12						38 36		
240	36 58			52 45			19 03			48 28		
270	29 22			58 23			26 20			58 18		
300	19 33			56 47			28 41			64 36		
330				49 02			25 13			63 09		

Altitudes are based on Declination and SHA in the May-August 1943 American Air Almanac

Figure 132—Computed Altitudes, Form B (Page 24 of 30 pages)