GROUND LESSON 2

LESSON OBJECTIVE:

The student will be introduced to basic helicopter design and the helicopter components.

LESSON CONTENT:

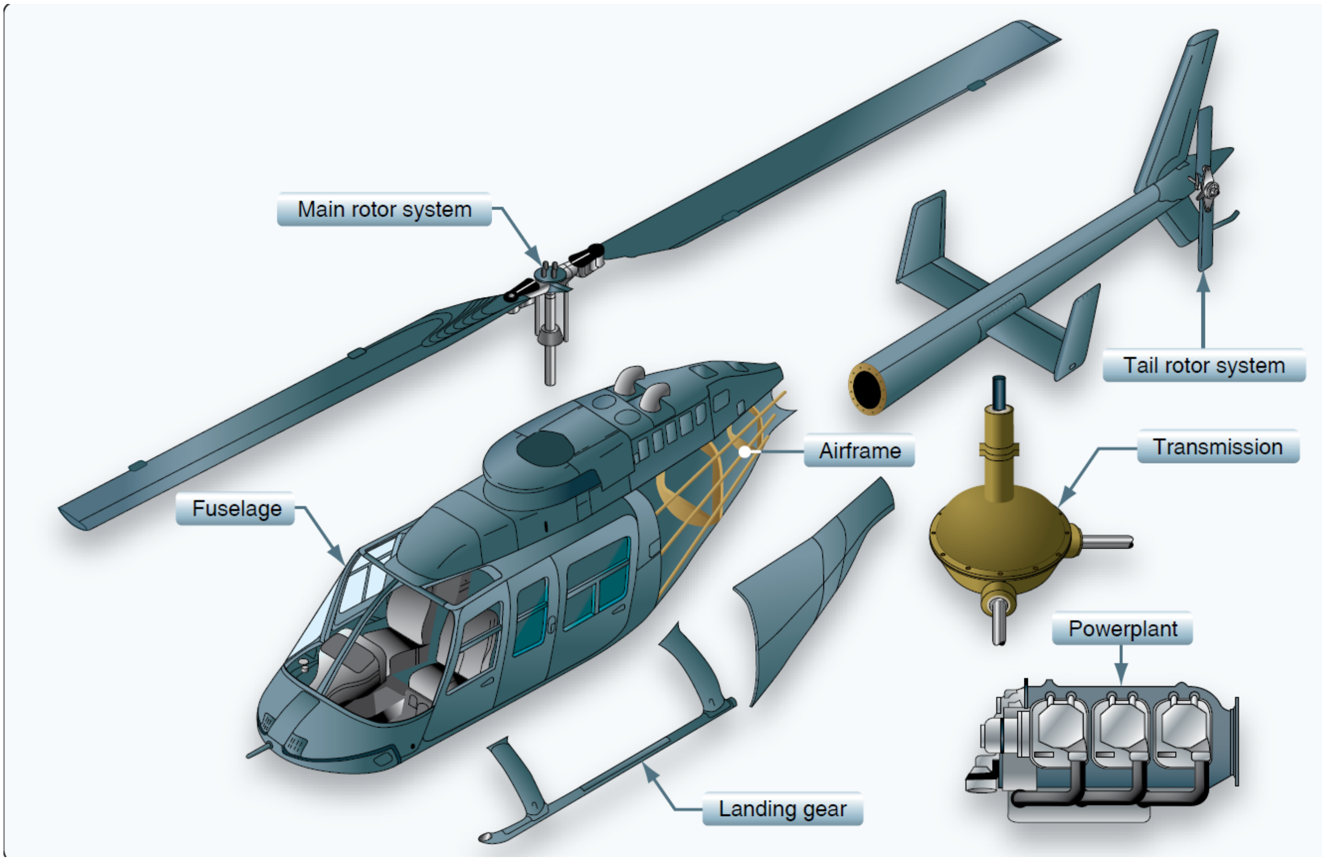
A. Helicopter components
-Main rotor
-Tail rotor
-Transmission; main and tail
-Swashplate assembly
-Drive train and tail boom
-Clutch; centrifugal, friction drive
-Powerplant (Basics)
Principles Piston vs. Turbine
Magneto system
B. Flight controls
-Cyclic
-Collective
-Throttle
-Pedals
C. Electrical system
-Battery
-Generator
-Circuit breakers
-Aircraft lights; navigation/position, anti-collision, landing lights
D. Fuel and fuel system
-Proper grade fuel
-Fuel system operation
-Fuel contamination; preventive measures, elimination
of contamination in fuel
-Refueling procedures and grounding
E. Oil and oil system, hydraulic system if appropriate
-Oil; type and quantity
-Oil system operation
-Hydraulic system; type, hydraulic fluid used, servicing
F. Instruments
-Function, markings, and limitations
-Dual tachometer
-Manifold pressure gauge
G. Flight instruments, function, markings, and limitations
-Pitot static source

-Alternate pitot static source
-Airspeed indicator; indicated airspeed, calibrated airspeed, true airspeed
H. Pressure altimeter
-Indicated altitude
-True altitude
-Pressure Altitude
-Absolute altitude
I. Vertical speed indicator
J. Gyroscopic instruments
- functions, markings, limitations
-Principle of gyroscope
-Gyroscope errors
-Power sources; vacuum system, electrical system
-Attitude indicator
-Turn and slip indicator
K. Magnetic Compass
-Compass errors

COMPLETION STANDARDS:

This lesson will be complete when, by oral examination, the student displays an understanding of the material presented. Recommended study material for this lesson: Basic Helicopter Handbook chapter 4 and 5, Helicopter Pilot Manual chapter 1, section A, chapter 2, and the Pilot Operating Handbook (System Description). Recommendation is for the instructor to spend some lesson time identifying components on an actual helicopter

2.1. Helicopter components



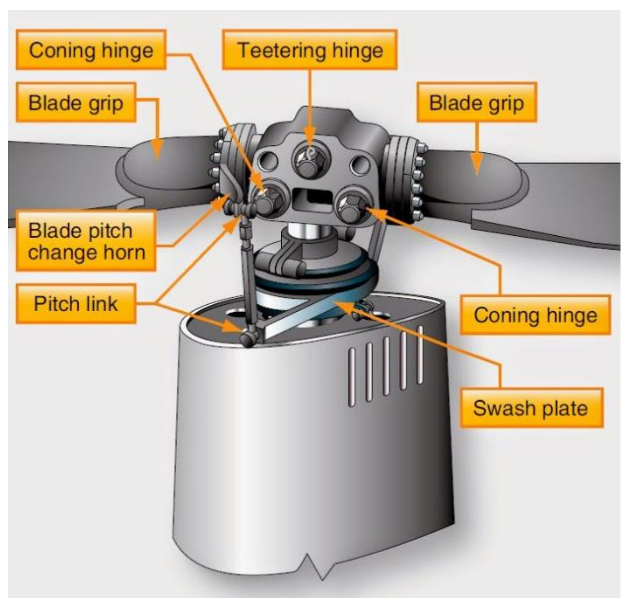
HFH 4-1

MAIN ROTOR(HFH Ch4)

Rotating airfoil that generates lift

Consist of:

- A mast
- Rotor hub
- 2 or more rotor blades
- Swashplate
- Control tubes, pitch links



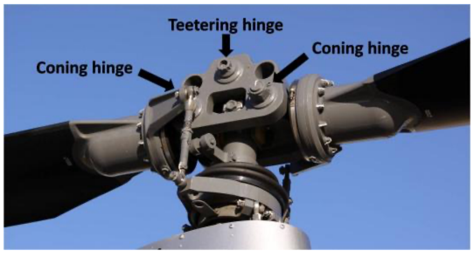
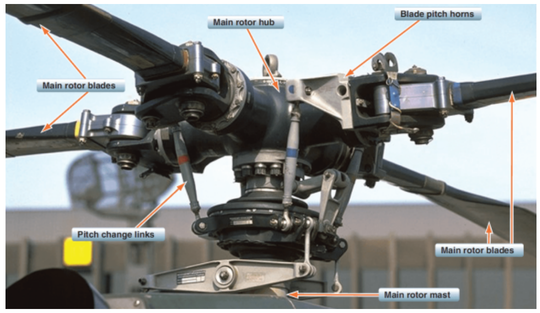
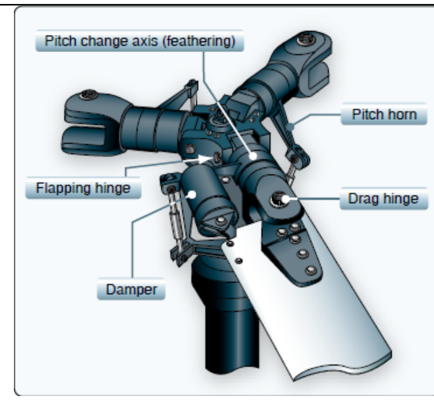
Three different types

- Rigid rotor system
  - Only feather
  - They compensate for flapping, by bending
    Operating loads absorbed by material bending rather than by hinges
- Semi-rigid rotor system
  - Feather and flapping
  - Two blades
    Blades rigidly attached to the rotor hub
  - Rigid in plane

- Teetering hinge allows flapping as a unit

- Fully articulated

- Each blade can feather, flap, lead/lag independently
- Dampers prevent excessive lead/lag of the blades
- Lead/lag compensates for Coriollis effect

 Semi-rigid	 Rigid HFH 4-4	 Fully-articulated HFH 4-9

Compare with three types:

Type	Advantages	Disadvantages
Rigid	-Crisp response -Mechanically simple	-More vibrations -Structurally complex -Expensive -Mast Moment
Semi-rigid	-Easy to hangar	-Slower response: Fewer blades
Fully-articulated	-Crisp response -Stable and less vibrations	-Mechanically complex:More drag -Expensive -High MX cost

TAIL ROTOR(Antitorque System)4-7

Counteracts the torque produced by the Main rotor

Consist of

-Shaft

- Swashplate
- 2, or more blades
- Hinges, bearings, pitch links

Directional control in hover operated with pedals

Three types of Tail rotors

-Conventional tail rotor

2 blade system (R22)

Teetering Delta Hinges

Reduces flapping

Offset hinge mechanically alters the pitch angle by using a pivot point

AoA is increased

Tail rotor can be placed closer to tail boom

increases structural strength

Less weight

Less vibration

- **Fenestron**

Several small blades “fan in tail”

Angle in-between the Blades are off-set, to reduce noise

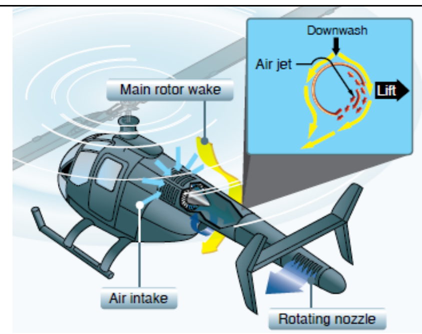
-NOTAR

<u>No</u> <u>T</u>ail <u>R</u>otor uses Main Rotors downwash

Utilizing the Coanda effect

Conventional

Fenestron



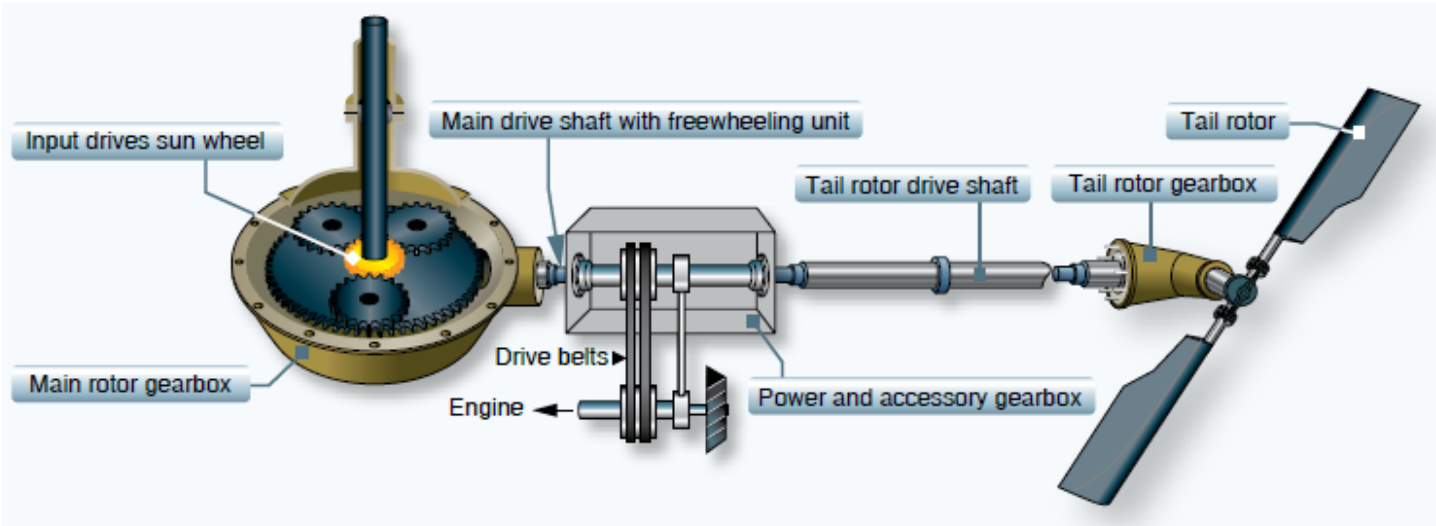
NOTAR(HFH4-15)

Compare with each type:

Type	Advantages	Disadvantages
Conventional	-Delta hinge reduces - Flapping - Weight - Vibrations	-Less efficient than Fenestron -Foreign object can easily damage system -Noisy
Fenestron	-More efficient than a conventional Tail Rotor -Quiet -Safer for foreign objects	-Shrouded fan decreasing performance Therefore a more RPMs are needed which requires more power -Increased weight due to the shroud □ -Expensive
NOTAR	-No foreign objects can damages the system -Reduces vibration	-Slower reaction

TRANSMISSIN:MAIN AND TAIL

HFH 4-16



Changes direction of rotation and RPM of the driveshaft, mounting point for Main rotor and Tail rotor

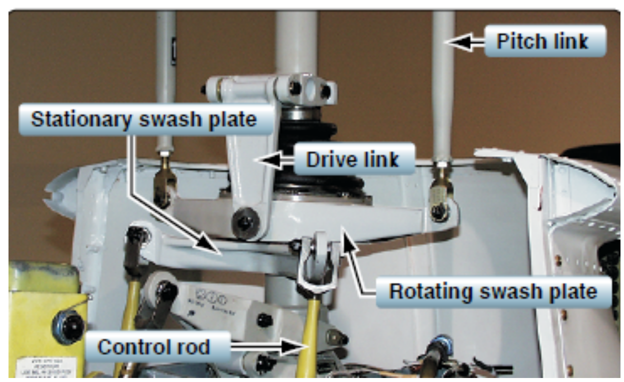
Adjust the outcome RPM from the engine to an optimum RPM for the MR and TR

SWASHPLATE ASSEMBLY (HFH 4-11)

Transmits control inputs from the cyclic and collective to the rotor system

Allows control inputs from a stationary assembly through to a rotating assembly

- Consists of
  - Rotating swashplate
  - Stationary swashplate
  - Pitch links
  - Bearings
  - Control rods



DRIVETRAIN AND TAIL BOOM

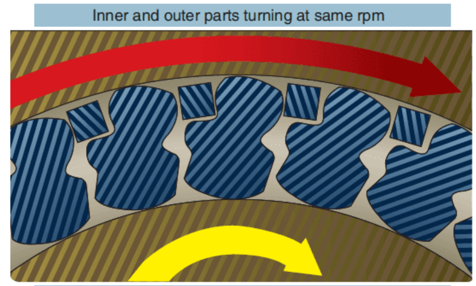
Transmits power from the engine to the gearboxes and then on to MR and TR

CLUTCH; CENTRIFUGAL AND FRICTION DRIVE

Freewheeling unit (sprag clutch) 4-7

- Consist of inner assembly and outer drum
- As engine RPM's are increased the centrifugal force slings clutch shoes outward towards the outer drum. The friction starts to turn the outer drum
- Automatically disengage rotor from the engine, in case of an engine failure
- Allows helicopter to autorotate
- R22 uses a sprag clutch

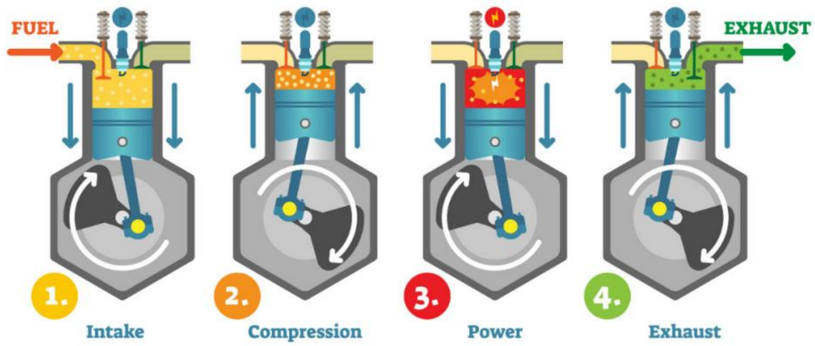
Inner and outer parts turning at same rpm



Outer turning much faster than inner

Located inside the upper pulley around the transmission shaft
Friction Clutch allows engine to be started without engaging the rotor system
- Clutch actuator lifts upper sheave to tension double V-belt
- Rotor system can be gradually engaged

Powerplant (Basics)
Power plant provides power to the helicopter
Mounted on to the fuselage
Reciprocating (piston)
- Four stroke engine
  1. Intake
  2. Compression
  3. Power
  4. Exhaust

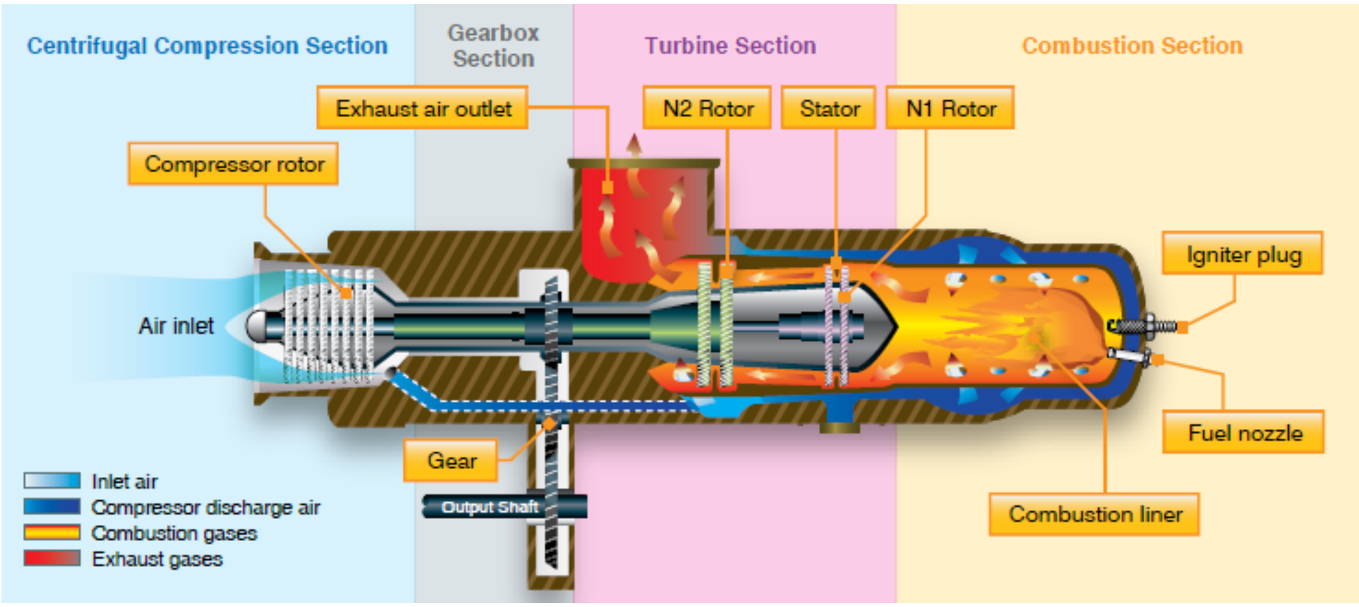


<u>POWERPLANT – PISTON VS. TURBINE</u>

Piston
- Like a car
- Engine is mounted backwards in the R22
  - The front of the engine is located faced the Tail Rotor
- A 15:1 fuel/air mixture is ignited by sparkplugs
- Explosion forces pistons to move up and down
- Pistons connects to a crankshaft
- Crankshaft converts vertical motion to rotating motions

Turbine (4-9)
- Continuous operation
- Compressor draws filtered air in and compresses it
- The air is directed to combustion section and mixed with fuel
- Fuel/air mixture is ignited by the continuously burning flame
- Combustion gas is forced through a series of turbine wheels, causing them to turn
- Turbine wheels provides power to intake compressor, and gearbox
- Operating RPMs can vary from 20,000 to 51,600

（https://animagraffs.com/inside-a-jet-engine/）



Compare:

Piston	Turbine
Good: Good reliability Low fuel consumption Low price maintains Cheap	Good: Less weight High power High efficiency
Bad: Heavy & big Less power/weight ration	Bad: Expensive High MX High fuel consumption

MAGNETO SYSTEM

The R22 engine is fitted with two AC (alternator current) magnetos

Located just behind the firewall

Self-containing
- The magnetos are independent of any other power supply
- Connected direct to the crankshaft
- Once the engine is started, the magnetos will keep running
- Provides electrical power to the sparkplugs

Redundancy
- Engine fitted with two magnetos
- If one fails, the other will keep the engine running
- Both magnetos are connected to every cylinder

 8 sparkplugs

Engine performance
- 2 sparkplugs per cylinder
□ Provides one magnetos to be able to run engine, if the other magneto dies
- Double sparkplug gives better engine performance and safety
- Rough or week engine performance could indicate a magneto failure

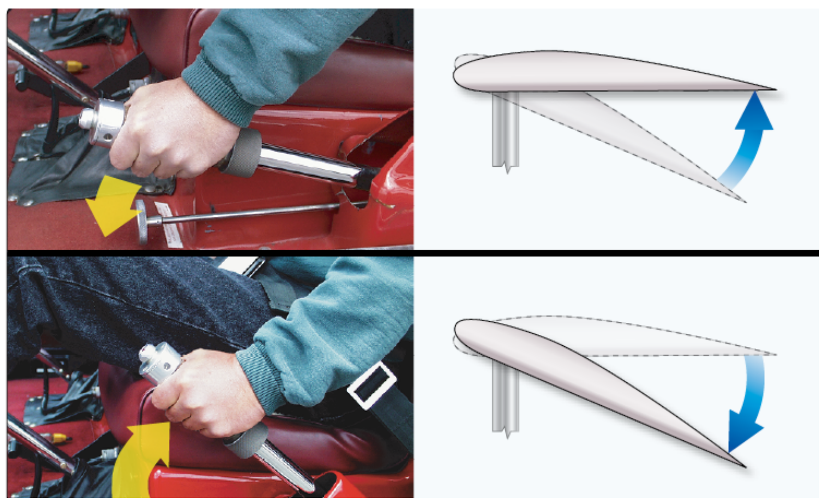
2.2. Flight controls (Ch3)

CYCLIC

Individually controls the rotor blades pitch angle in its cyclic of rotation
- Tilts the disc
- Determines the direction of flight, airspeed

Different designs
- Robinsons "handlebar" – two pilot "sharing" the same cyclic
- Conventional design – one cycle for each pilot

COLLECTIVE



Collectively increasing or decreasing pitch angle on all rotor blades
- Allows the main rotor to create more or less lift

□ Position and appearance
- Like a hand brake in a car
- Left of the pilots seat
- Controlled with left hand

THROTTLE

□ Controls the engines power output / RPM
□ Located on the front end of the collective is a twist/grip handle that controls the throttle and RPM of the engine
□ Different flight situation requires different power setting
□ Rpm control aids

- Correlator

Mechanically opening or closing butterfly valve as collective is raised or lowered

- Governor

Maintains the engine RPMs by sensing and applying corrective throttle inputs

□ Only active above 80 % engine PRMs
□ On/Off switch located at front end of throttle grip

PEDALS(Antitorque Pedals) (HFH 3-5)

□ Control thrust of TR to counteract the torque produced by MR
□ Used to control your trim in flight, and to turn the helicopter in a hover
□ Pedal inputs transmitted to TR via control rods

2.3. Electrical system(Based on POH 7-11)

BATTERY

- 12 volt DC
- 25 ampere
- Supplies power to the starter
- Backup for limited time if alternator fails
- Located on left side aft of cabin, or in cabin under the instrument panel

ALTERNATOR – R22

- 14 volt Alternating Current
- 60 Ampere
- Converts Alternating Current to Direct Current -> AC/DC
- Charges the battery
- Main power supply to the electrical system
- Uniform power supply even at low engine RPM

GENARATOR

- Most likely found in bigger helicopters that needs more electricity
- Compared to an alternator
  - Good
    - Produces DC (direct current) power
  - Bad
    - Heavier
    - More MX
    - Less output when engine is idling
      Requires more power to be driven

CIRCUIT BREAKERS

- Protects the electrical circuit and electrical components from an overload
  - Pops out when overloaded
    - Does not need to be replaced

FUSES

- A fuse is supposed to burn if there is a over-voltage in the circuit
- Two fuses on the R22
  - Clutch actuator – located next to warning light test
  - Clock – located on firewall behind passenger seat

AIRCRAFT LIGHTS; NAVIGATION/POSITION, ANTI-COLLISION, LANDINGLIGHTS

- Navigation/position
  - Enables you as a pilot to identify other aircrafts, and their direction of flight
  - The lights are covered so etc. green can only be seen from the front right side
  - Colors
    - Green on right side
    - Red on left
    - White on the tail boom
- Anti-collision/strobe light

- Flashing red light mounted on top of the tail-boom
- Strobe has to be turned on before engine start, and until blades stop spinning

 Landing lights

- R22 has two landing lights mounted in the nose of the helicopter
- One angled for normal approach and one angled for autorotation
- According to the POH, both landing lights has to be operational during night ops

FUEL AND FUEL SYSTEM (R22POH 2-7)

PROPER GRADE FUEL

 Fuel grades

- **80/87 Red**
- **100LL Blue**
- **100/130 Green**
- **115/145 Purple**
- **Jet A Clear**

 If required fuel grade is unavailable, always use a higher grade

 POH does allow us to use a lower fuel grade then 100LL, but lower fuel grade makes an engine run rougher. So don't do that

 If blue and green get mixed, it will turn clear, just like Jet A

FUEL SYSTEM OPERATION

 Gravity feed vs. fuel pump (HFh4-22)

- Gravity feed

 Tank over the carburetor, no assistance in pushing fuel to engine

 Vents prevents from creating vacuum suction

- Fuel pump

 Tank can be anywhere since a pump is pumping the fuel to the engine

 Shut-off valve

- Between the tank and the fuel filter/carburetor. Disconnects the tank from the system in case of emergency

 Measurement (gauge/stick/clock/warning light)

- Gauge is not precise. Only needs to be correct when empty.
- Stick – Good visualization of fuel in tank (ensure the correct side is used for the correct tank)
- Clock – Good average usage of fuel, will depend of amount of power used and is a rough estimate of available fuel
- Warning light – NOT TO BE USED FOR TRACKING FUEL

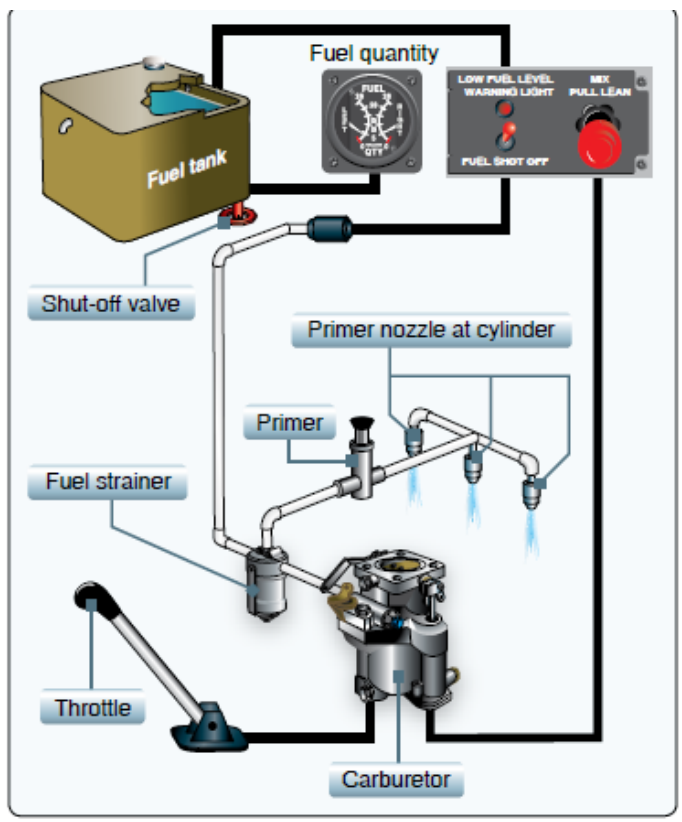


Figure 4-22. *A typical gravity feed fuel system, in a helicopter with a reciprocating engine, contains the components shown here.*

□ R22 Fuel burn per hour
- BETA – 9 Gallons
- BETA II – 10 Gallons

□ R22 Fuel Capacity (R22 ch2-8)

Tanks with bladders	Total capacity US gallons(liters)	Usable capacity US gallons(liters)
Main tank	18.3(69)	16.9(64)
Auxiliary tank	9.7(37)	9.4（36）
Combined capacity	28(106)	26.3(100)

FUEL CONTAMINATION; PREVENTIVE MEASURES, ELIMINATION

□ Contamination are things such as
- Water
- Dirt particles
- Dirty fuel

□ Preventive measures
- Clean around tank cap before opening
- Always put cap back on fuel truck hose after fueling
- Recommended to refuel after last flight of the day, to prevent condensation

□ Elimination
- Gascolator at lowest point in fuel system works as a fuel filter
- Take fuel samples from Gascolator and fuel drains after refueling, before flight
- Check the fuel for

□ Impurities, dirt particles, dirty fuel

REFUELING PROCEDURES AND GROUNDING(R22 POH7-10)

□ Ground aircraft with ground wire from fuel truck
- Static spark can ignite fuel

□ Verify that Master switch is off

□ Verify proper fuel
- If right fuel not available, use next grade up
- **NEVER use lower grade** than approved by POH
- Indications of wrong fuel grade

□ Lower grade can cause **detonation –** (uncontrolled explosion, engine runs rough, noise level increase, temperatures goes up!)

□ **Permanent damage to engine!**

□ Always use a ladder when available to make sure that the fuel nozzle goes straight into the tank. A nozzle that's leaning up against the sidewall, will cause damage to the tank

□ After refueling
- Make sure filler caps on correctly
- Remove ground wire

DETONATION AND PREIGNITION

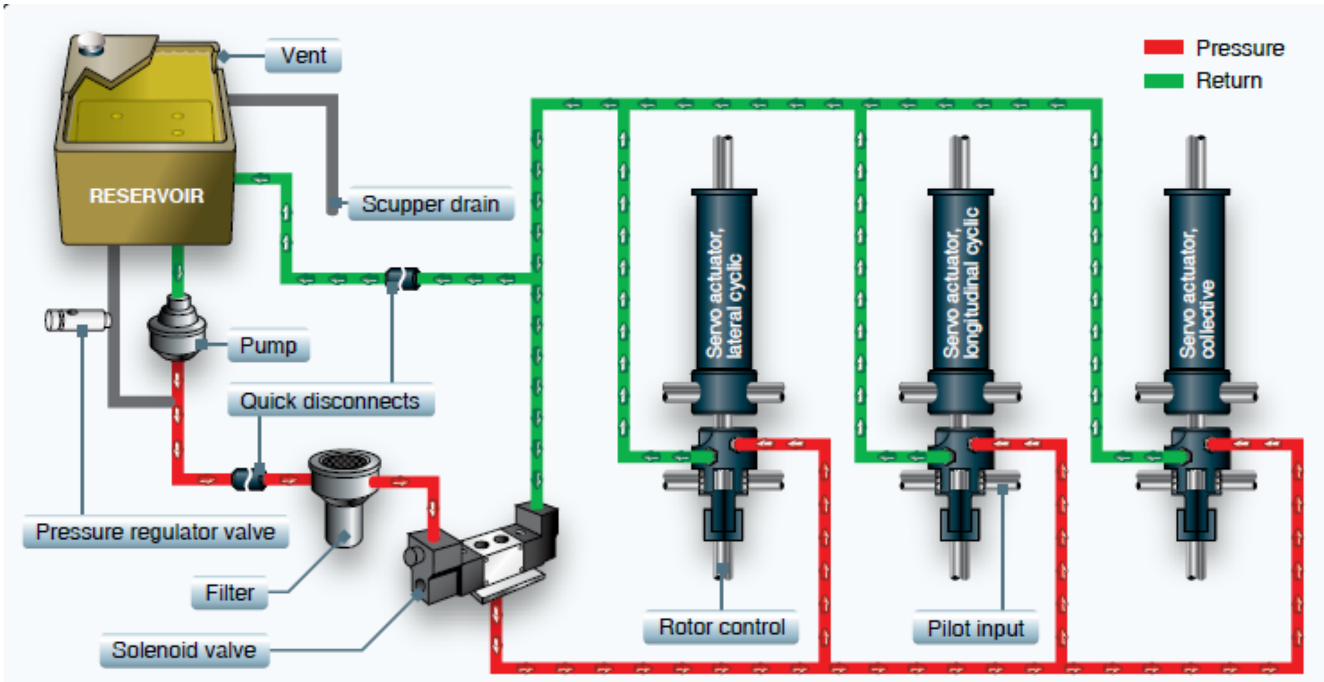
 Detonation can happen due to a high temperature or a bad/low fuel grade. A low fuel grade will not withstand the compression when the piston moves toward the cylinder head during the compression stroke. The fuel will explode too early during the stroke, causing a loss on power, instead of controlled burn. This could lead to permanent engine damage. It will sound like the engine I "knocking"
 Pre-ignition can happen when a hot spot in the cylinder, caused by chunk of carbon or a damage sparkplug, ignites the fuel-air mixture prior to the desired ignition point during the stroke

2.4. Oil and oil system, hydraulic system if appropriate

OIL; TYPE AND QUANTITY
 Ashless Dispersant or Mineral oil
 Minimum 4 quarts (HAA 5 quarts)
 Maximum 6 quarts
OIL SYSTEM OPERATION
 The oil system cools and lubricates the engine
 Reducing friction/wear as well as temperatures
 Consists of
- Oil
- Oil sump – Bottom of the engine – collects oil after passing through engine
- Oil pump – driven by engine , pressurize oil and transfers to parts
- Oil filter – Collects dirt and metal particles – changeable
- Oil cooler – Maintain the right oil temperature

 Maintenance
- For every 50 hours or four months, whichever occurs first

 If no oil filter is installed, change oil for every 25 hours
Hydraulic system; type, hydraulic fluid used, servicing



- Used in almost every helicopter, except smaller piston engine helicopters
- Installed to overcome high control forces
- Consists of
    - Servos for each flight control
    - Hydraulic pump, usually driven by the Main rotor so it still works during engine failure
    - Hydraulic fluid reservoir
- The hydraulic system can be switch On and Off
    - Solenoid valve is open when the system is switch on, allowing hydraulic fluid to enter the system
    - Vice versa, when the system is turned off
- Pilot is allowed to maintain control of the aircraft, due to the hydraulic oil in the actuators

2.5. Instruments

FUNCTION, MARKINGS, AND LIMITATIONS (Based on R22 POH ch2)

- Gives indications of engine or rotor performance
- Color codes for instrument markings
    - **Red** Indicates operating limit. Edge of red line indicates limit. Pointer should not enter red during normal operation
    - **Yellow** Precautionary or special operating procedure range
    - **Green** Normal operating range
- Limitations
    - Engine tachometers

R22	O-320	O-360
Upper Red Arc	104-110%	104-110%
Green Arc	97-104%	101-104%

Lower Arc	90-97%	90-101%
Yellow Arc	60-70%	60-70%

- Rotor tachometers

R22	O-320	O-360
Upper Red Line	110%	110%
Yellow Arc	104-110%	104-110%
Green Arc	97-104%	101-104%
Yellow Arc	90-97%	90-101%
Lower Red Line	90%	90%
Yellow Arc	60-70%	60-70%

- Power off

☐ Maximum 110 %

☐ Minimum 90%

- Airspeed indicator

☐ Green arch 50-102 KIAS

☐ Red line (Vne) 102 KIAS

- Oil pressure

☐ Lower red 25 psi

☐ Lower yellow arc 25-55 psi

☐ Green arc 55-95 psi

☐ Upper yellow arc 95-115 psi

☐ Upper red line 115 psi

- Oil temperature

☐ Green arc 75 to 245°F (24 to 118°C)

☐ Red line 245°F (118°C)

- Cylinder head temperature

☐ Green arc 200 to 500°F (93 to 260°C)

☐ Red line 500°F (260°C)

- Manifold pressure

☐ O-320 engine (R22 Beta)

Yellow arc 21.0 to 25.2 in. HG

Red line 25.2 in. HG

☐ O-360 engine (R22 Beta II)

Yellow arc 19.6 to 24.1 in. HG

Red line 24.1 in. HG

- Carburetor Air temperature

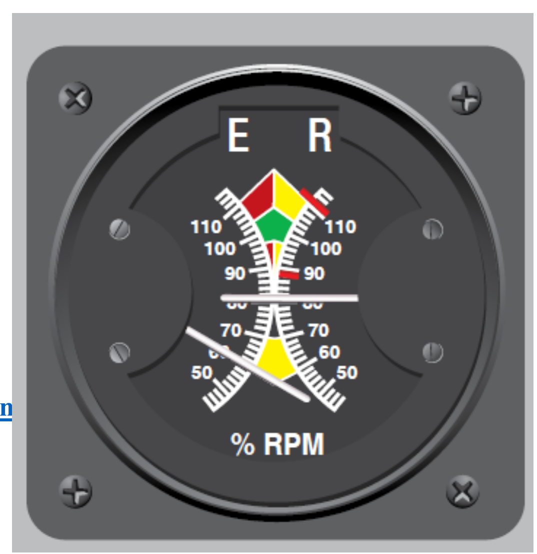
☐ Yellow arc -15 to 5°C

DUAL TACHOMETERS

☐ Left needle represents engines rpm in percent(POH 1-6)

☐ Right needle represents rotor rpm in percent

☐ Avoid 60-70% when rotor engaged – sympathetic



resonance

MANIFOLD PRESSURE GAGE

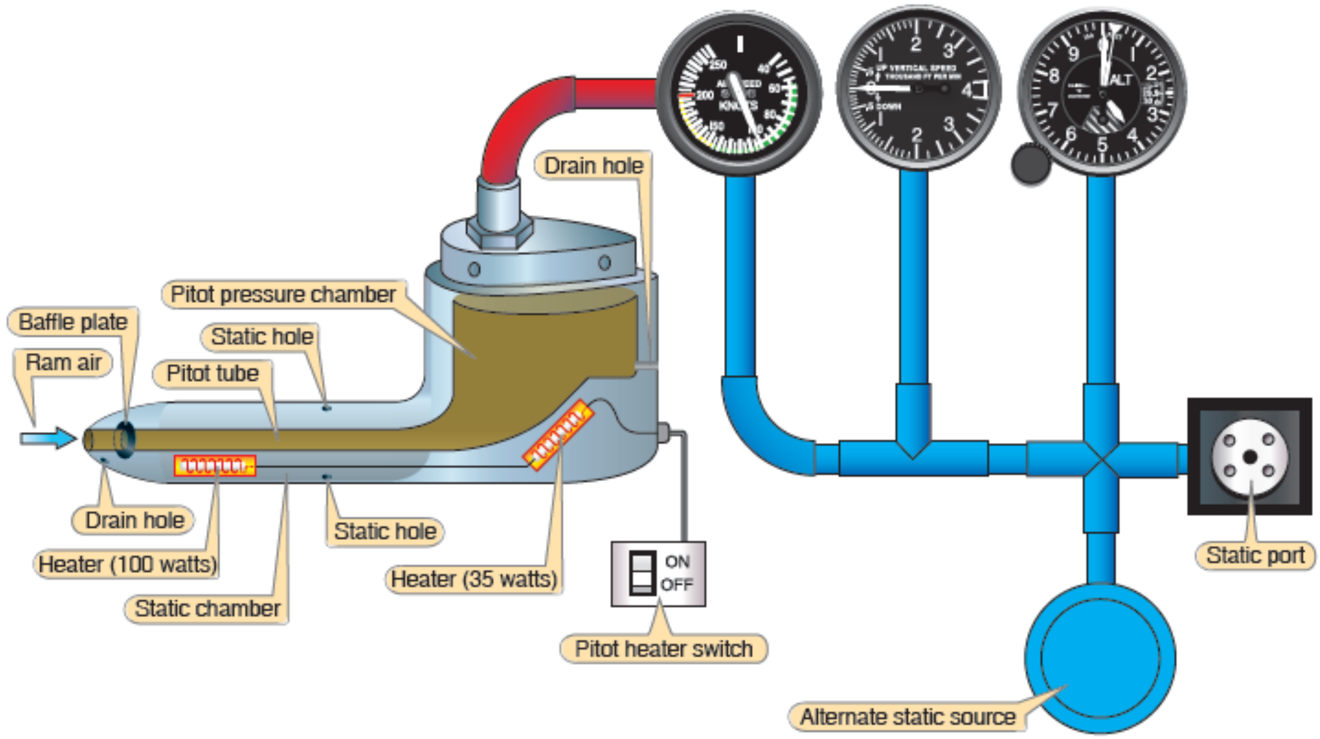
 Used to determine engine throttle setting

 Measures vacuum pressure going into the engine

 Manifold Air Pressure (MAP) is determined by chart for given pressure altitude and Outside Air Temperature (OAT)

2.6. Flight instruments, function, markings, and limitations

PITOT STATIC SOURCE（ifh5-3)



Pitot tube

- Small tube in front of aircraft
- Source for dynamic pressure
- Drain hole prevents water from collecting
- Sometimes heated to prevent ice (mostly in IFR ops)
- Used by

    Airspeed indicator (ASI) in conjunction with Static port

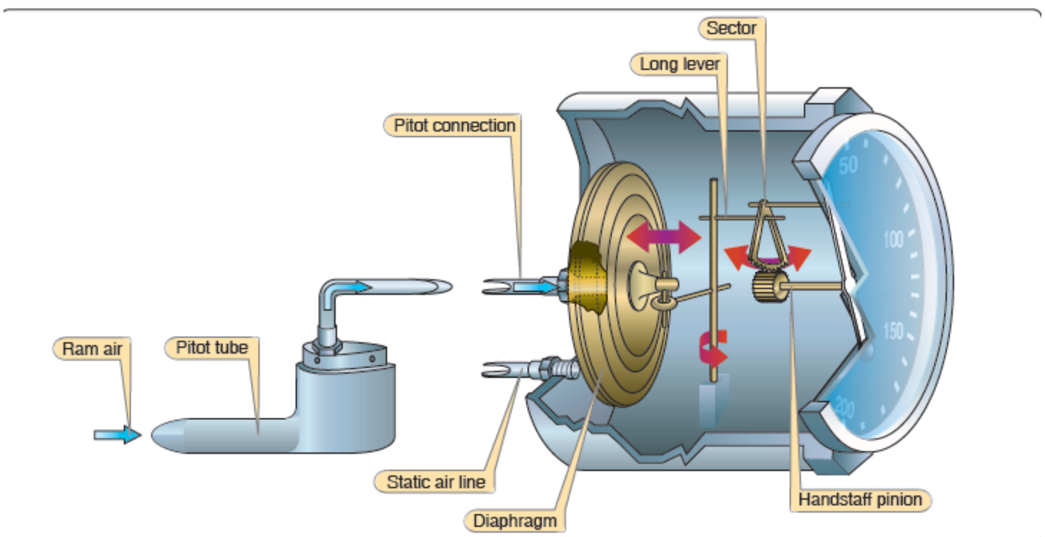
Static port

- White hose located in cowlings
- Collects ambient air (atmospheric pressure)
- Used by

Airspeed Indicator (ASI) in conjunction with static port
Vertical Speed Indicator (VSI)
Altimeter (ALT)
- Can also be located on side of a/c like R44
- Alternate static source, sometimes located in cabin, otherwise break VSI glass in an emergency

Pitot-static system blockage
- Can be blocked by:
  Dirt, ice, bugs
- Always check sources during preflight
- Will indicate big errors if blocked
- **Blocked pitot tube**
  ASI affected
  Pitot tube blocked and drain hole open – ASI reads zero
  Pitot and drain hole blocked:
  At same altitude – ASI reads the same even if airspeed increased/decreased
  Climb – IAS increase
  Descent – IAS decrease
- **If static port blocked**
  ASI, VSI and ALT are affected
  Altimeter doesn't change
  VSI indicates zero
  ASI – Altitude above where static port blocked will indicate less airspeed
  and altitude below where static port blocked will indicate more airspeed

AIRSPEED INDICATOR



Indicates aircraft speed through the air

Compares dynamic pressure against static pressure
- Ram air impacts on diaphragm
- Bigger difference Greater airspeed

Types of speed
- **Indicated airspeed**
  - Read on your ASI, subject to instrument and position errors
- **Calibrated airspeed**
  – Indicated airspeed corrected for instrument and installation errors
  Calibrate airspeed according to POH 5-2
- **True airspeed**
  - Actual airspeed, calibrated airspeed corrected for altitude and nonstandard

temperature. As pressure and density decrease with altitude, IAS will be lower than true airspeed

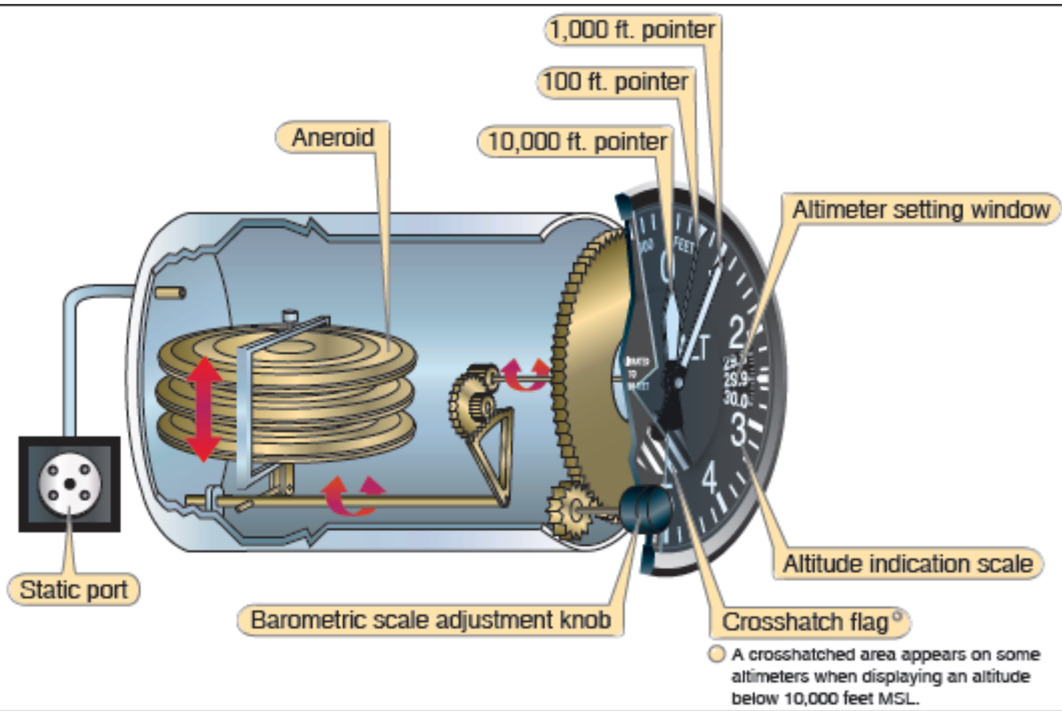
- **Groundspeed**
  - Your actual speed over the ground
    True airspeed corrected for wind
    Headwind decreases groundspeed, Tailwind increases groundspeed
    Airspeed indicated by a GPS

<u>Limitations on the airspeed indicator</u>

- Calibrated to ISA.
- Not for actual atmospheric conditions
- Small effect at low airspeeds
- R22 is limited to 102 knots (kts) -> VNE at sea level up until 3000 density altitude
- VNE decreases as density altitude increases

-Alternate pitot static source

2.7. Pressure altimeter



-Indicates height of aircraft above a given pressure setting
-Aneroid wafers contains a pressure of 29.92 "Hg
-When the ambient pressure from the static source decreases around the aneroid wafers, the altimeter will indicate a higher altitude, and vice versa

INDICATED ALTITUDE

- -What is shown on the altimeter
- - Height above Mean Sea Level (MSL) when set to current altimeter setting

TRUE ALTITUDE

- -The vertical distance of the aircraft above sea level – the actual altitude

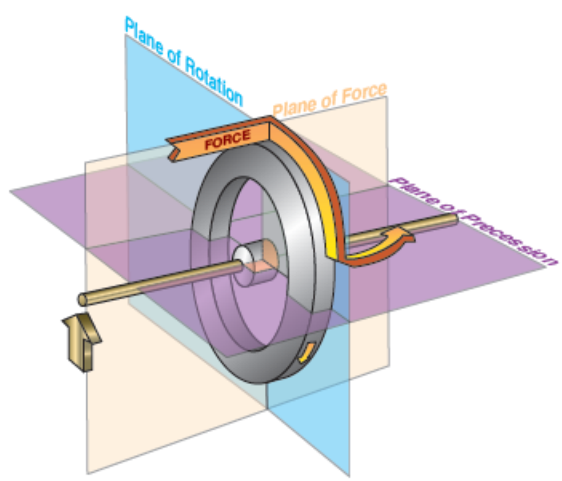
 -Expressed as feet above MSL
PRESSURE ALTITUDE
 -The altitude above standard datum plane when altimeter is set to 29.92 “Hg
 -The altitude indicated when altimeter is set to 29.92 “Hg
ABSOLUTE ALTITUDE (HEIGHT)
 -The vertical distance of an aircraft above the terrain
 -Expressed as feet Above Ground Level (AGL)

2.8. Vertical speed indicator

FUNCTION
 -Measures the rate of climb / rate of descent
 -The diaphragm has a direct source from the static port
 -As pressure inside the diaphragm is decreased as the aircraft climbs, the diaphragm will decrease and indicate a climbing trend, and vice versa
 -The Calibrated leak causes a pressure differential that is indicated as a climb or descend
 -If climb or descent is continued, needle will stabilize after 6-9 seconds and indicate rate of climb
 -Calibrated leak causes a lag that
LIMITATIONS
 -Initially not accurate
 -Therefore it not only gives you a rate, it also gives you trend of what is going on
 -Delay in accurate display of vertical speed
 -Calibrated leak causes the pressure to equalize after about 6 to 9 seconds
 -Non correct readings when
- In turbulence – quick changes
- Abrupt control inputs

2.9. Gyroscopic instruments

PRINCIPLE OF GYROSCOPE
 Any spinning object exhibits gyroscopic properties
 Two fundamental properties of gyroscopic action
- Rigidity in space
 Principle that a gyroscope remains in a fixed position in the plane in which it is spinning
 If a spinning bicycle wheel is held with two hands, it’s acting like a gyro, there for it is much harder to change the plane it’s spinning in, compared to changing the plane when it’s not spinning
- Precession
 Precession is the tilting or turning of a gyro in response to a deflective force
 The reaction to this force, does not occur where the force is applied, but 90 degrees later in the direction of rotation
This allows the gyro to sense the amount the aircraft is turning



This applies to gyroscopic instruments because they are suspended in gimbals and when the aircraft turns, a small force is applied-Principle of gyroscope

-Gyroscope errors

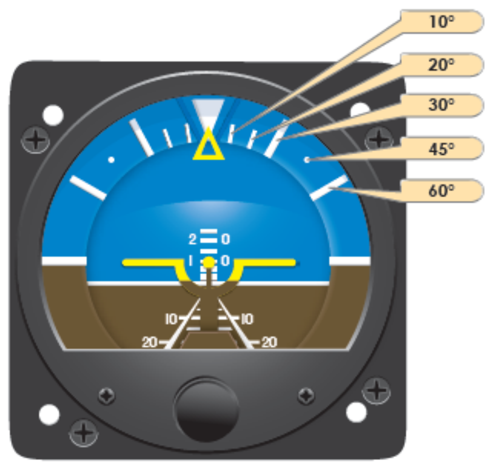
Power sources; vacuum system, electrical system

• Aircraft and instrument manufacturers' designs redundancy into flight instrument systems, in case one of the systems fails, there is a backup system.

• Different sources of powering the gyroscopic instruments

- Electrical source, which is used in R22 instrument trainers
  - • Instruments driven by electric motors
  - • Electricity supplied from separate bus bar for redundancy
- Vacuum system
  - • Air is sucked through instruments and spins them by help of scooped wheels
  - • Vacuum pressure gauge installed in cockpit to verify correct pressure(ifh 5-18)

ATTITUDE INDICATOR



• Gyro acts as an artificial horizon

• Mounted in double gimbal – allows the gyro to pitch and roll

• Top of the instrument is blue – indicates the sky

• Bottom of the instrument is brown – indicates the ground

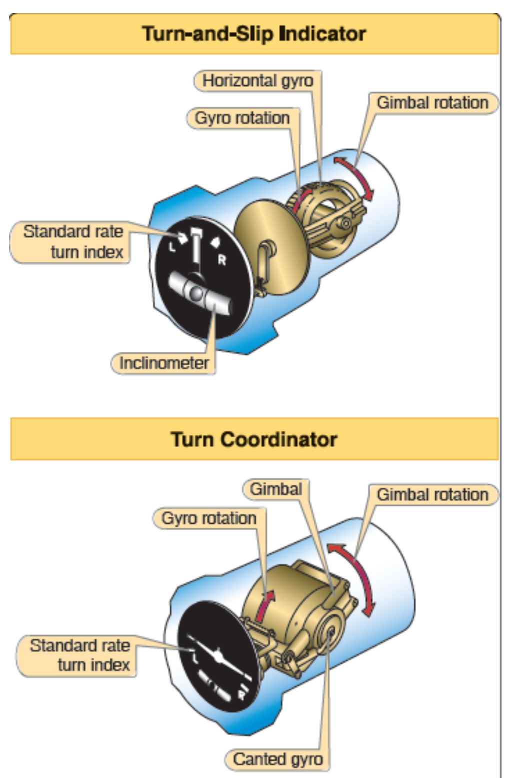
• Orange bar indicates aircraft

• Bank index on top of instrument - 10º, 20 º, 30 º, 60 º and 90 º

• Limitations

- Turning Error
  - • Precession causes gyro to turn towards the inside of a turn
  - • Most visible when turning 180°
- Acceleration Error
  - • Quick accelerations cause small pitch up due to precession.
- Deceleration
  - • Causes horizon to dip down, causing a false indication of pitch down attitude

TURN AND SLIP INDICATOR



• Turn and slip indicator

- Can only indicate rate of turn
- Gyro mounted on single gimbal
- Turn indicators works with gyroscopic precession
- Inclinometer – ball in fluid measures skid and slip
  - • Indicates the relationship between the angle of bank and rate of yaw

 Turn Coordinator

- Can indicate rate of turn and rate of roll
- Senses rotation around both the roll and yaw axis
- Gimbal frame canted about 30º from the longitudinal axis, allows it to sense rate of turn and rate of roll

2.10. Magnetic Compass(ifh5)

MAGNETIC FIELD OF THE EARTH

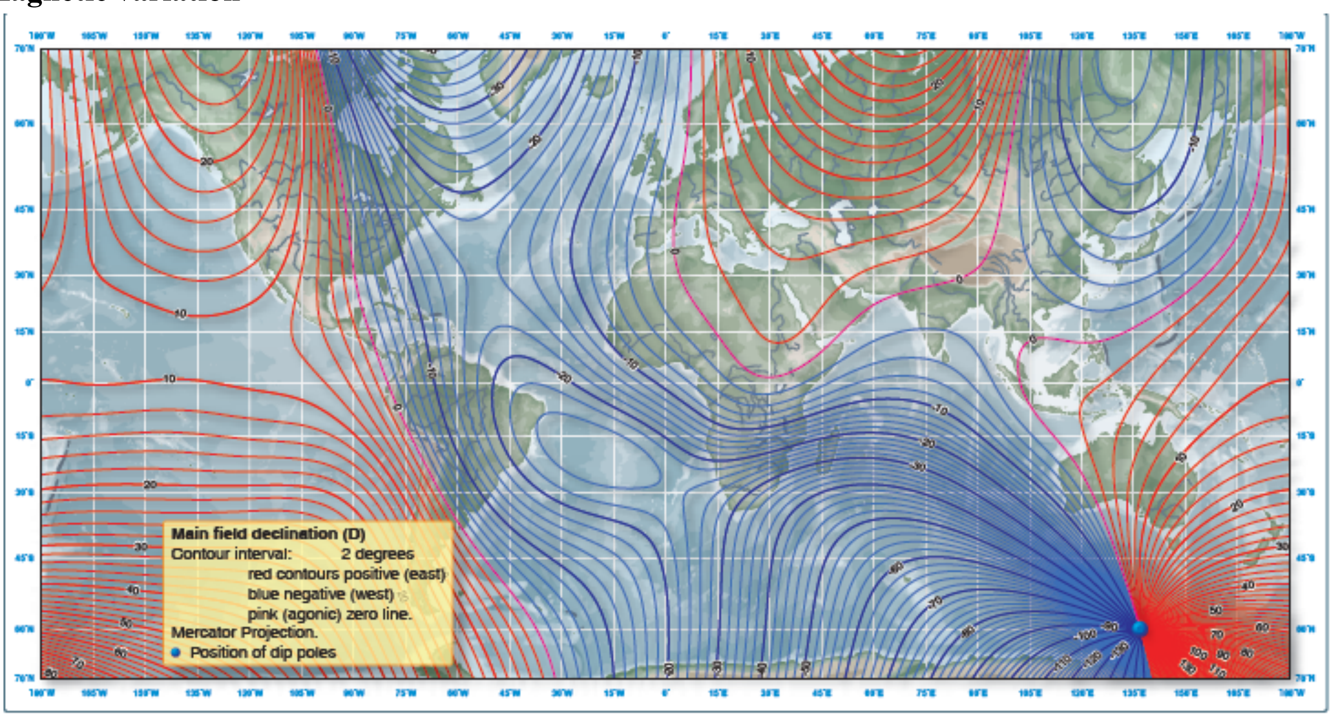
 Earth is a huge magnet, spinning in space surrounded by a magnetic field
 Magnetic field made up by lines of flux
 Leaves the surface at the magnetic North pole and reenter at the magnetic South Pole
With Lines of flux are two important characteristics

- Any magnet that is free to rotate will align with them
- An electrical current is induced into any conductor that cuts across them

Magnetic Compass Errors

The magnetic compass is the simplest instrument in the panel, but it is subject to a number of errors that must be considered.

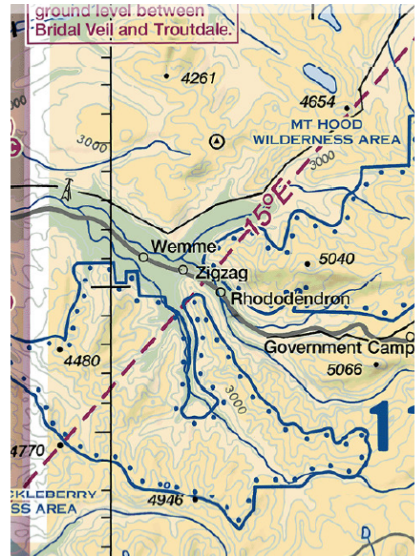
Magnetic variation



Isogonic lines are lines of equal variation.

 Magnetic variation is the difference between true north and magnetic north in angles

- True north geographic point – the North pole
  - Magnetic north is what the compass needle is pointing at



- Described in East and West
  - East is negative, west is positive (east – least / west – best)
- Magnetic poles are moving all the time and therefore don't coincide with true north/south
- Isogonic lines printed on charts
  - Needs to be calculated with when flight planning

Correction for Variation

Step 1: Determine the Magnetic Course

True Course (180°) ± Variation (+10°) = Magnetic Course (190°)

Step 2: Determine the Compass Course

Magnetic Course (190°, from step 1) ± Deviation (–2°, from correction card) = Compass Course (188°)

To find true course when the compass course is known, remove the variation and deviation corrections previously applied:

Compass Course ± Deviation = Magnetic Course ± Variation= True Course

- **TVMDC**

  True North: 360°

  Variation (TTD): E (-15°)

  Magnetic Deviation: 360° – 16° = 344°

  Compass deviation card: Check the aircraft compass deviation

Compass deviation

- Metal and instruments inside the helicopter creates magnetic fields
- Distorts the earth's magnetic field
- False reading of the compass
- Compass deviation card – specific for every aircraft

FOR	000	030	060	090	120	150
STEER						
RDO. ON	001	032	062	095	123	155
RDO. OFF	002	031	064	094	125	157

FOR	180	210	240	270	300	330
STEER						
RDO. ON	176	210	243	271	296	325
RDO. OFF	174	210	240	273	298	327

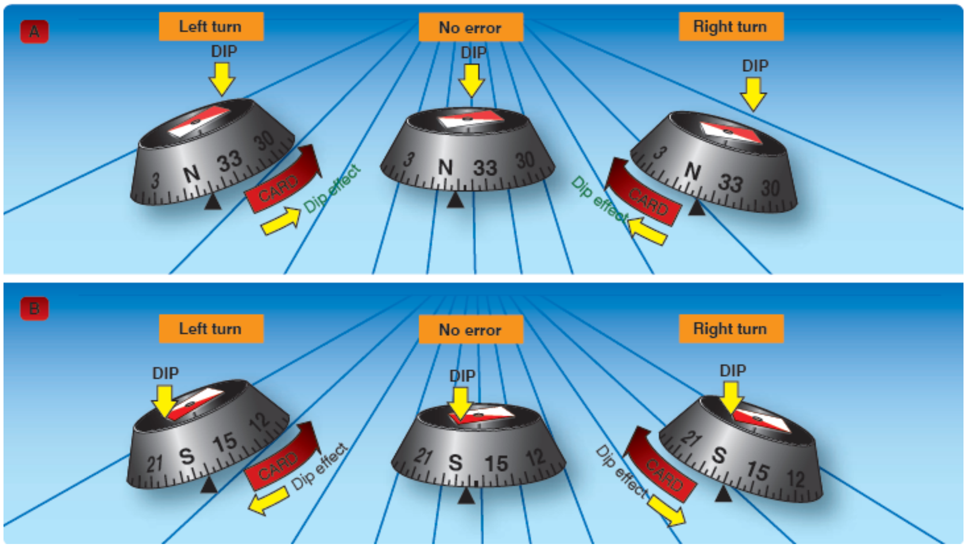
Acceleration / Deceleration Error

- Most noticeable on west / east headings
- **ANDS – Accelerate North Decelerate South**
  - In the northern hemisphere, the compass swings to the north while accelerating the aircraft, and swings to the south while decelerating
  - When speed stabilized the compass reads correct again

Turning Error

- Most noticeable when turning from or into a northerly or southerly heading

- **UNOS – Undershoot North Overshoot South**
- When an aircraft turns the magnetic dip will cause the needle to “fall down” pointing to the earth
- This causes an initial indication of turning east when turning west from a northerly direction
- Northern vs. southern hemisphere – dip errors opposite



Resource
Instrument Flying Handbook ch5
R22 POH ch2&5
Helicopter Flying Handbook Ch3&4