at a set rate. Unlike older, bidirectional pumps, the dry-pump turns in only one direction. To provide maximum life, the vanes are canted at a carefully calibrated angle, making it essential that the pump be installed correctly. A pump that has been dropped should never be put into service. The carbon vanes and rotor are surprisingly fragile, and while there may be no visible sign of damage, internal damage may have occurred.

For gyros to work properly, exact vacuum (or pressure) must be maintained, despite the potential for system fluctuations caused by power surges, de-ice-boot inflation, and engine-speed changes. The gyro instruments are protected from excessive vacuum by a regulating valve. Under normal operating conditions, the pump draws more air than is necessary to operate the gyros, so the valve regulates the airflow by drawing from an alternate air source that bypasses the gyros. Similar to the vacuum system, the pressure system has a regulation valve that serves to relieve pressure by allowing excess air pressure to escape prior to entering the gyro instruments.

The vacuum gauge needle responds directly to the amount of suction in the tubing that passes by the gauge. In twin-engine aircraft, where there is one pump per engine, the gauge has a pump-failure alerting mechanism. Inside the vacuum gauge—out of the sight of the pilot—two small red balls are held independently by the suction of each engine-driven pump. If, for instance, the left engine fails, its corresponding pump will also fail and there will no longer be suction on the left red ball. A small spring, normally held back by the suction, now pushes the ball into the view of the pilot. Pilots must be cautious, however, as this is not necessarily a reliable indication of engine failure. The windmilling propeller of a failed engine may keep the vacuum pump operating normally. In that case, the red indicator would not appear until the pilot feathers the prop.

A pressure gauge works essentially the same as a vacuum gauge in both single-engine and multiengine aircraft. Both types of gauges should read approximately in the middle of the green arc during normal operations.

Modern fittings and tubing are designed for maximum airflow. While the tubing in older pneumatic systems often had sharp, 90-degree turns, modern systems are engineered with less acute bends. Even the design of the tubing itself is geared for minimum flow resistance because hose cracks, twists, crimps, and improper internal dimension can lead to significant airflow problems and may seriously decrease the life of the pump.

Pneumatic system filters capture impurities in the air, safeguarding the gyro instruments. Clean air is essential for unrestricted airflow, protection of delicate gyro instruments, and pump longevity. Most gyro problems can be traced back to system contamination. At the head of the list are dust, women's face powder (avoid the need to powder your nose before landing), cigarette smoke, dirt, some cabin-cleaning agents, and dry fire-extinguishing agents. It is the job of various filters to protect the system from these contaminants.

The inlet air filter is the primary system filter; it removes most major pollutants from the air before they enter the system. The vacuum system has a garter-type foam inlet filter that cleanses the air as it enters the regulating valve. In the pressure system, the inlet filter is located just upstream from the pump itself. An "in-line" filter, which comes between the pump and the instruments, is used in the pressure system to trap the carbon lubricating particles before they enter the gyro instruments.