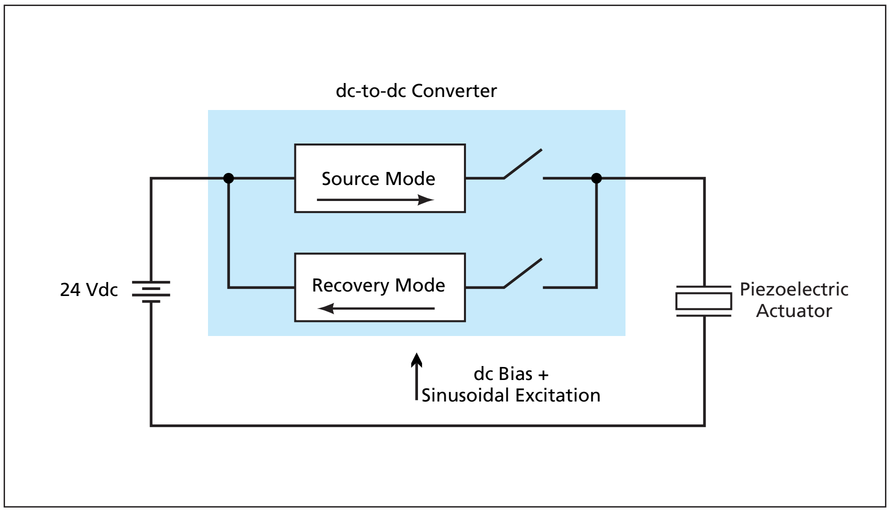


Figure 2. This **Circuit Would Recover Energy** returned by the piezoelectric actuator during each cycle of oscillation, thereby minimizing the power demand of the pump.

push the diaphragm to the right, causing the volume of the fluid chamber to decrease, and thereby expelling fluid from the chamber. The fluid would enter and leave the chamber through check valves.

The piezoelectric stack would be driven electrically to make it oscillate at the resonance frequency of the spring-and-mass structure. This frequency could be made high enough (of the order of 400 Hz) that the masses of all components could be made conveniently small. The resonance would amplify the relatively small motion of the piezoelectric stack (a stroke of the order of 10 μm) to a diaphragm stroke of the order of 0.5 mm. The exact amplification factor would depend on the rate of damping of oscillations; this, in turn, would depend on details of design and operation, including (but not limited to) the desired pressure rise and volumetric flow rate. In order to obtain resonance with large displacement, the damping rate must be low enough that the energy imparted to the pumped fluid on each stroke is much less than the kinetic and potential energy exchanged between the mass and spring during each cycle of oscillation.

To minimize the power demand of the pump, a highly efficient drive circuit would be used to excite the piezoelectric stack. This circuit (see Figure 2) would amount to a special-purpose regenerative, switching power supply that would operate in a power-source mode during the part of an oscillation cycle when the excitation waveform was positive and in a power-recovery mode during the part of the cycle when the excitation waveform was negative. The circuit would include a voltage-boosting dc-to-dc converter that would convert between a supply potential of 24 Vdc and the high voltage needed to drive the piezoelectric stack. Because of the power-recovery feature, the circuit would consume little power. It should be possible to build the circuit as a compact unit, using readily available components.

This work was done by Michael G. Izenson, Robert J. Kline-Schoder, and Martin A. Shimko of Creare, Inc. for Johnson Space Center. For further information, contact the Johnson Commercial Technology Office at (281) 483-3809.
MSC-23112

Improved Quick-Release Pin Mechanism

Lyndon B. Johnson Space Center, Houston, Texas

An improved quick-release pin mechanism supplants a prior such mechanism in which the pin bears a shear load to hold two objects together. The prior mechanism, of a ball-locking design, can fail when vibrations cause balls to fall out. The load-bearing pin is an outer tube with a handle at one end (hereafter denoted the near end). Within the outer tube is a spring-loaded inner tube that includes a handle at its near end and a pivoting tab at its far end. The pin is inserted through holes in the objects to be retained and the inner tube is pushed against an offset pivot inside the outer tube to make the tab rotate outward so that it protrudes past the outer diameter of the outer tube, and the spring load maintains this configuration so that the pin cannot be withdrawn through the holes. Pushing the handles together against the spring load moves the locking tab out far enough that the tab becomes free to rotate inward. Then releasing the inner-tube handle causes the tab to be pulled into a resting position inside the outer tube. The pin can then be pulled out through the holes.

This work was done by Jay M. Wright of Johnson Space Center. For further information, contact the Johnson Innovative Partnerships Office at (281) 483-3809.
MSC-23298

Designing Rolling-Element Bearings

Marshall Space Flight Center, Alabama

Bearing Analysis Tool (BAT) is a computer program for designing rolling-element bearings for cryogenic turbomachines. BAT provides a graphical user interface (GUI) that guides the entry of data to develop mathematical models of bearings. The GUI breaks model data into logical subsets that are entered through logic-driven input screens. The software generates a three-dimensional graphical model of a bearing as the data are entered. Most data-entry errors become immediately obvious in the graphical model. BAT provides for storage of all the data on a shaft/bearing system, enabling the creation of a library of proven designs. Data from the library can be transferred to subsequent projects by use of simple cut-and-paste routines.

BAT includes a library of temperature-dependent cryogenic bearing-material properties for use in the mathematical models. BAT implements algorithms that (1) enable the user to select combinations of design and/or operating-condition parameters, and then (2) automatically optimize the design by performing trade studies over all of the parameter combinations. This feature enables optimization over a large trade space in a fraction of the time taken when using prior bearing-model software.

This program was written by James D. Moore, Jr., and Ed Troy of SRS Technologies for Marshall Space Flight Center. Further information is contained in a TSP (see page 1). MFS-31864-1.

Reverse-Tangent Injection in a Centrifugal Compressor

The compressor flow can be stabilized against stall and surge.

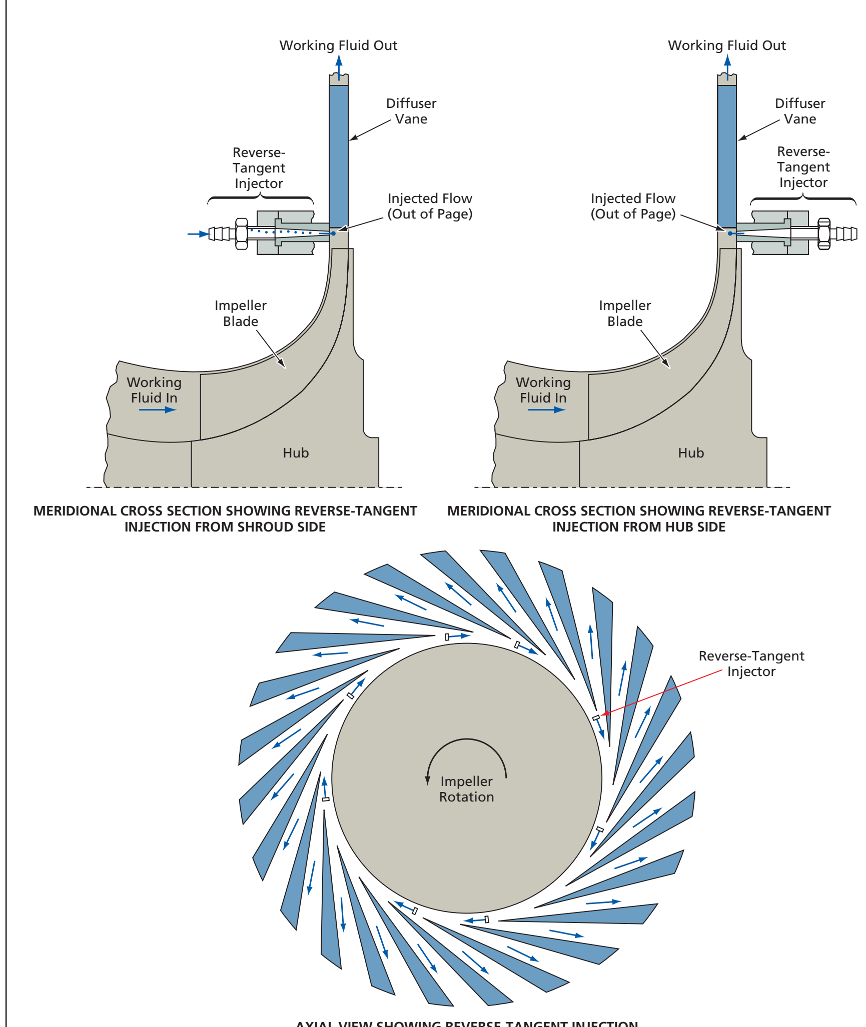
John H. Glenn Research Center, Cleveland, Ohio

Injection of working fluid into a centrifugal compressor in the reverse tangent direction has been invented as a way of preventing flow instabilities (stall and surge) or restoring stability when stall or surge has already commenced. If not suppressed, such instabilities interrupt the smooth flow of the working fluid and, in severe cases of surge, give rise to pressure and flow oscillations that can be strong enough to damage the compressor and adjacent equipment.

The invention applies, in particular, to a centrifugal compressor, the diffuser of which contains vanes that divide the flow into channels oriented partly radially and partly tangentially. In reverse-tangent injection, a stream or jet of the working fluid (the fluid that is compressed) is injected into the vaneless annular region between the blades of the impeller and the vanes of the diffuser (see figure). As used here, “reverse” signifies that the injected flow opposes (and thereby reduces) the tangential component of the velocity of the impeller discharge. At the same time, the injected jet acts to increase the radial component of the velocity of the impeller discharge. The net effect is to turn the impeller discharge flow toward a more radial direction; in other words, to reduce the flow angle of fluid entering the vaned diffuser passage, thereby reducing diffusion ahead of the passage throat, reducing the pressure load and the incidence of flow on the leading edges of the vanes. The reduction of the flow angle also changes the dynamic coupling between the impeller and diffuser in such a way as to prevent the development of certain instability modes in the diffuser.

The number and distribution of reverse-tangent injectors can be tailored to match the expected stall/surge characteristics of the compressor and the space available for installation. Reverse-tangent injection can be implemented in any of three operating modes:

1. Continuous operation, in which the working fluid is injected continuously;
2. Open-loop operation, in which injection is initiated by on-off valves upon detection of compressor instability or conditions known to precede compressor instability and the injection is



Working Fluid Is Injected in the direction opposing the tangential component of impeller discharge velocity at multiple points (eight in this example) in the vaneless region between the impeller blades and the diffuser vanes.