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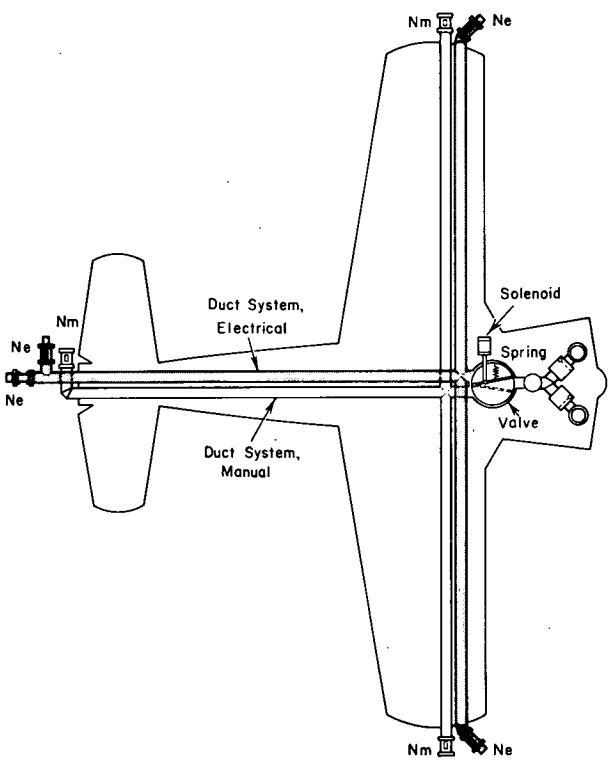
NASA TECH BRIEF

Ames Research Center

Attitude Controls for VTOL Aircraft

The attitude-control jet nozzles of a VTOL aircraft may be operated by mechanical connection to the pilot's control stick and pedals. However, it is desirable and often necessary to increase the flexibility of the attitude control system by incorporating an electrically-controlled set of nozzles operated by servomotors. Thus, the attitude control systems currently in use consist of a single duct system with two sets of reaction control nozzles, one linked mechanically to the pilot's controls, and the other set driven by electric servomotors which are commanded by preselected combinations of electrical signals generated by the pilot, rate gyros, or other signal sources. In such systems, the range of forces available for attitude control is only a portion of that provided by the compressed air source, because air is ejected from both sets of nozzles at all times even though only one set is being used for control. Moreover, the outputs of the mechanically-controlled and the electrically-actuated nozzles produce independent forces which may be additive or may work in conflict; when the forces are in conflict, there is little effective control power available to the pilot, and when they are additive, the amount of control input required for a given attitude maneuver will often require unexpectedly small pilot corrective actions..



It is obviously desirable to provide the pilot with the capability of deactivating completely either the electrically- or the mechanically-controlled system. However, the electrically-controlled servo systems that are currently employed require that the mechanically-controlled nozzles be inactivated either by physically disconnecting them from the pilot-operated controls or by using complicated systems for combining the two modes of operation. Moreover, since the time required to effect any changeover in the current systems is altogether too long to permit the pilot to switch from one mode of operation to the other in emergencies, and there is a reluctance of the pilot to depend on all-electric systems, it became necessary to seek an improved attitude control system.

The improved attitude control system developed for VTOL aircraft consists of two air distribution systems, one with electrically- and the other with

(continued overleaf)

mechanically-controlled jet nozzles which may be operated selectively from the same pilot input without interference. Moreover, if the mechanical system has been inactivated, it will be automatically reactivated upon failure of the electrical control system.

The system employs two sets of reaction nozzles which are displaced from various axes of the aircraft. Each set is fed by a separate duct system selectively connected to a source of gas under pressure, preferably bled off from a jet engine. For control about each orthogonal axis, nozzles of the first set (Nm) are controlled mechanically and nozzles of the second set (Ne) are controlled electrically by servo motors (see diagram).

A dual butterfly valve, interposed between the air supply duct and the ducts feeding the separate systems, is movable within less than one second into the position which will supply either system exclusively of the other. The valve is latched electrically in the electrical control position, and a spring biases the valve disc assembly so that the mechanically-controlled nozzles are placed into communication with their feed line if electrical power is interrupted. Hence, the attitude control system is returned to mechanical control immediately at the option of the pilot or by the failure of the electrical system. Since only one set of nozzles is operated at a given time, the full control force derivable from the compressed gas source can be applied to the control nozzles.

Notes:

1. The following documentation is available from:
   National Technical Information Service
   Operations Division
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)
   Reference:
   NASA TN D-5715 (N70-20725), A Reaction Attitude Control System for Jet VTOL Research Aircraft.
2. No other documentation is available. Specific questions, however, may be directed to:
   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B71-10202

Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,472,470) and royalty-free license rights will be granted for its commercial development. Inquiries about obtaining a license should be addressed to:

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