U.S. Gov't

file - Glover

Entry Date 5-11-93

Data Base HDOCNDX

Index # INS.0205982

ORAL HISTORY INTERVIEW

DATE OF DOCUMENT [Date of Interview] = 06 - 04 - 68

OFFICE OF PRIME RESPONSIBILITY = JSC

NUMBER ON DOCUMENT = 00

TYPE OF DOCUMENT [Code for Interview] = 1

PROGRAM [3-letter Program Archive code] = INS

AUTHOR [Interviewee's Last Name] = GENTILE

LOCATION OF DOCUMENT [Numeric Shelf Address] = 091-2

SUBJECT OF DOCUMENT: [use relevant bold-face introductory terms]

Oral history interview with Fred J. Gentile (See ~~also~~ Warren G. Glover for Interview Summary)
[full name of interviewee]

about ____________________
[main focus of interview]

____________________.

Title: 1968 - Crew Systems Sect, Systems Test Branch, Crew Syst. Div, E&D
[interviewee's current and/or former title and affiliation]

____

Interview conducted by ____________________
[interviewer's name/position]

____________________ **at** ____________________.
[location of interview]

Transcript and tape(s). [for inventory only: # pages ____; # tapes ____]

U.S. Gov't

Entry Date 5-11-93

Data Base HDOCNDX

Index # INS. 0205983

ORAL HISTORY INTERVIEW

DATE OF DOCUMENT [Date of Interview] = 06-04-68

OFFICE OF PRIME RESPONSIBILITY = JSC

NUMBER ON DOCUMENT = 00

TYPE OF DOCUMENT [Code for Interview] = 1

PROGRAM [3-letter Program Archive code] = INS

AUTHOR [Interviewee's Last Name] = GLOVER

LOCATION OF DOCUMENT [Numeric Shelf Address] = 091-2

SUBJECT OF DOCUMENT: [use relevant bold-face introductory terms]

Oral history interview with Warren G. Glover (See ~~also~~ also Fred J. Gentile ~~for full~~ ~~interview~~ ~~summary~~)
[full name of interviewee]

about MSC Flight Acceleration Facility - Centrifuge - Capabilities
[main focus of interview]

and Controls.

Title: 1963 - (Systems Evaluation Development Div. - Test Facilities
[interviewee's current and/or former title and affiliation]

1968 - Centrifuge Operations Section, Systems Test Branch, Crew Syst. Div, E+D

Interview conducted by Robert B. Merrifield, Staff
[interviewer's name/position]

Historian **at** MSC.
[location of interview]

Transcript and tape(s). [for inventory only: # pages 8; # tapes 1]

Master 1

U.S. Gov't

CONTENTS:

Biographical - [date/place of birth; family background]

Education -

Career Path -

Topics - 3-man Centrifuge for Apollo astronaut training; Rucker Co. contract; arm length; gimbal motions; centrifuge operational 1966; Apollo training; lift off and re entry profiles; suit + equipment tests; other man-rated centrifuges; unique feature - 3 men side-by-side; vacuum capability; vacuum cap failure; problems w/ gimbal ring; work w/ Corps of Engineers; digital computer control; pilot controlled re entry; Centrifuge control complex; safety system; automatic and manual stops modes; manned profile pre-test.

1338

INTERVIEW WITH WARREN GLOVER AND FRED J. GENTILE
June 4, 1968

GLOVER: When I came here it was October of 1962, and the feasibility studies had been completed on the centrifuge. The need for the centrifuge was justified mainly for training the Apollo astronauts, and one of r36 the reasons it was wanted was that the Navy centrifuge at Johnsville or similar facilities didn't have enough capabilities to meet Apollo requirements. In particular we needed a centrifuge to accommodate three people in the Command Module. The centrifuge at Johnsville just had a one-man capability.

Soon after I had gotten here, we went through a feasibility study with Ford, Bacon and Davis, the architect engineers. This same company got the design contract for the centrifuge. After the design was completed, r37 the construction contract was won by the Rucker Company. Both of r38 these were Corps of Engineers contracts but the Corps didn't have enough technical people to monitor these contracts so asked the particular section that I worked in, the Centrifuge Operation Section, to help them technically monitor the contract for the design and the construction of the centrifuge.

During the feasibility study it was decided that the optimum length arm would be 50 feet. A longer arm will cut down on coriolis force and r41 gyroscopic effects, but the price becomes excessive. We had a set amount of money for our budget and for that amount of money we built what we felt was the optimum length arm with no sophisticated control system beyond our means. We have two gimbal motions on the centrifuge: 1) the gimbal-gondola motion and 2) arm motion. The main reason for the gimbal-gondola motions is so that we can actually simulate the lift-off and reentries. We keep what we call the result of the g vector straight thru the man from the chest through the back with very limited side load or head to foot load. On the reentry of the Apollo or space flight reentry it's almost all ballistic reentry. We don't get side loads. We do get the load from the chest to the back and that's the main reason for our gimbal motion of our centrifuge.

We became operational in February of 1966, and since that time, we have run a number of programs that are related to Apollo, and one or two that were related to Gemini; we got into operation just a little bit too late to help support Gemini to any great extent. We have run astronaut training profiles on Apollo, we have run the extravehicular maneuvering unit, checked it, qual tested it, run tests on the Apollo hand controller, we have run test on the net couch evaluation, and the seat angle evaluation on the seat angle of the seat in Apollo to give the astronauts more leg room, we have evaluated this to see that they didn't get any adverse effects. We have run pad and max q aborts, run tests on the Apollo "BUBBLE" ~~double~~ helmet, and our latest test has been on the Apollo entry ~~module~~ monitor system.

A profile is the g's vs time that the astronauts would be subjected to during lift-off and reentry. We run lunar profile ~~lunar~~ reentries if they were returning from the lunar mission. We ~~would~~ ran reentries where they were just earth orbital missions. What we simulate is the g part of this profile and get their reaction under g's to find out if they can perform their functions under the g loading during these profiles.

A normal Apollo profile lift-off runs around four or five g's and the normal reentry runs from 6 to eight ~~to ten~~ g's. Some pad aborts go up to

14 or 15 g's. The most we have ever run a man to in this centrifuge has been a 15 g profile. We evaluated the Apollo suit up to 20 g's with dummies--pressurized and non-pressurized. The centrifuge is good to 30, but it is red lined at 20 g's, ~~and it gets very uncomfortable over 15 g's~~. There is no place in Apollo where over 15 g's is expected, although there is some talk about an 18 g reentry. We haven't had any requirements thus far to run a man over 15 g's.

We also conduct tests on the suit, or as it is referred to--the pressurized garment assembly (PGA)--and all the other equipment, the helmet, the helmet bag and the unitized couch. We are preparing to test the foldable couch to perform design verification of it.

There are probably three to five man-rated centrifuges in the country. Johnsville is quite similar to ours, but not quite as large (it's a 2-man gondola). Wright Field has one, but I believe it's not in use now. It's also smaller. There is one at Brooks which is quite a bit smaller. Ames has one under construction. There used to be one at Pensacola and may still be in use. Compared to ours, it is very old. The Brooks centrifuge is strictly used in research and Johnsville is primarily for research, although it is used for other work, and in fact, it was used by our astronauts before our centrifuge was built.

The MSC centrifuge is unique in that it is the only facility that can accommodate three men riding simultaneously side-by-side. I believe that it is its only really unique feature. ~~Possibly~~ It has a larger payload. It can accommodate a three thousand-pound payload, whereas I believe the Johnsville unit has a thousand-pound payload. Our facility is larger but not necessarily a significant advancement in the state-of-theart.

GENTILE: There are not a whole lot of things a centrifuge can do. Other than the Johnsville centrifuge, ours is the only one with the control gimbal and gondola. The Wright Field machine has a very short arm, and I believe it is built to investigate violent motions more than acceleration in general, as is our machine.

GLOVER: One of the design criteria of our centrifuge was a vacuum capability. The Rucker Company had a subcontract with Lockheed Aircraft Services to build honeycomb caps for a 12 foot gondola capable of supporting a vacuum. Up until this time so far as I know, there had been no centrifuge with vacuum capabilities. Johnsville had tried several times but their caps had failed. The caps that Lockheed built for us, failed during the acceptance testing. The top cap, which has the door in it, imploded. Lockheed made an extensive investigation of the failure, made a few design changes in the caps, rebuilt them and the second time we tested them they did stand up under the established requirements of 3 mm of mercury or the equivalent of approximately 1~~5~~25,000 feet altitude. To my knowledge this is the first set of vacuum caps that have ever been built and successfully tested, for this type of operation. The requirements, of course, call for a vacuum during 30 g's of acceleration on a dynamic machine.

Another problem we had was in our gimbal ring, which supports the gondola. The gimbal ring is constructed of high strength stainless steel and an all welded construction. At the time there wasn't a great deal of knowledge on the welding capabilities of this steel and during the acceptance test of the gimbal ring we had a failure at 100% design load. One of the corner joints of the gimbal ring failed. We went back to the contractor and after a study of the problem, it was decided that the gimbal ring, although it failed, was repairable. So the gimbal ring was stiffened across the critical joints, again underwent the static test, and this time it passed. The gimbal ring failure was quite expensive. It cost us in the neighborhood of $800,000 and a schedule slip of about a year. When the vacuum caps failed, we didn't lose but about two months.

As far as working with the Corps of Engineers was concerned, I think all in all things worked out well. We did the technical monitoring and they did most of all the paper work, took care of the money matters. When change orders were necessary, we would evaluate them technically, and some time Corps people would ask our opinion of how much we thought the cost should be; otherwise, money matters were looked after by the Corps of Engineers and our Facilities Division.

We accepted the facility in February of 1966 and it took us about another year to a year and a half to iron out the minor operating problems. The contractor on the whole, did a creditable job, with the budget he had to work with. We inherited an undue number of problems in the control circuitry, controls, and with our electro-hydraulic gondola gimbal drive system. But these have been solved and we have a very good machine.

GENTILE: The control power of the machine was furnished as part of the prime contract but the contractor did find a subcontractor for electronics, the Video Corporation of San Diego which has since gone out of business. They were probably going out of business at the time they finished this project, which left us with some problems which had to be overcome in the long run. The major control part of the centrifuge is two digital computers that are linked together with a common memory bank. We went out on the limb a little bit on this aspect because no one had ever tried this type of control for a centrifuge. Johnsville, for example, found analog computers to be successful. But studies that we made and were confirmed by the contractors showed that our approach was a little cheaper and had more capability than the analog computer. All the controls are oriented toward operating the centrifuge. The main drive motor which is dc and the electro-hydraulic drive that operate the two gimbals leave a little extra capability for simulation. The tests operated in the centrifuge are very much like those on ground base simulators like a link trainer or like Apollo trainers. Both use FDAI (eight balls or altimeters) to give a pilot an idea what his atmosphere is actually like at the time he is running the centrifuge under the g forces.

We are now working on a pilot controlled reentry. This is one of our major goals.

The control complex consists of an operator's control room, that is in the direct view of the centrifuge. There is where the centrifuge operator sits, and he has various controls so that he can use to provide the mode of operation whether it be automatic or manual. But the actual controlling force are the computers which I spoke about earlier. They are located in a room on the ground floor, while the operator's room is on the second floor. In addition to the computer complex, the ground floor houses the data collection complex and all the servo electronic equipment. The third room is across an entrance hallway from the centrifuge, and the operator's control room, and it's for the use of the medical monitor. There, all of the signals brought out from the various medical sensors are monitored so that the doctors can have real-time data from the three men that may be participating in that test. In each of these rooms are a number of recorders. There are a total of 500 channels, which include some areas that must be monitored constantly during operation. Another three hundred channels pass digital test data through a multi-plexer. In addition, there are a number of other channels such as for the medical sensors which I spoke of that come in directly without any sort of processing to the area where they are displayed. The full capability of this centrifuge has not been tapped yet, because the tests have not been that extensive but in the post-Apollo period, the centrifuge will be able to take bigger and bigger programs.

~~GLOVER: I think too the philosophy behind the design parameters of the centrifuge called for greater capability than really was needed by just the Apollo program.~~

GENTILE: The centrifuge has quite an extensive safety system. The biggest portion of the safety system is an electronic device which monitors around 60 or 70 items at all times. These consist of various temperatures in the main motor, current in the main motor, pressures in the various systems, etc. Many of these things have established limits such as accelerometers in the centrifuge. They detect independently things that go wrong while the program is being performed within limits that are set up by the tests. If one of these accelerations should become too high or to the far end of a band, the centrifuge would automatically stop. Also, into this system we have built in what is called a manual stop mode. The astronaut or the centrifuge subject can terminate a test himself by simply pushing a button. The medical monitor also has the capability of terminating the test should he wish. The operator has the greatest capability of terminating tests. He has at his disposal three different stop modes. He can stop via computer or if he feels the computer is not operating correctly, he may stop the main motor in either of two ways--regenerative braking and dynamic braking. The dynamic braking works if everything is out, if there is a general electrical failure at the site. The centrifuge operator would use a separate battery system to stop the centrifuge and let the subjects get out. The operation of the centrifuge is quite safe, if anything it is a little over instrumented and many people have wondered how we get all of these safety items up and running.

GLOVER: We have made almost 4,000 individual test runs on the centrifuge. Of these, 600-700 have been manned runs. During all of this manned testing we have never had any subject ever instigate a stop mode himself. In other words, none of the subjects so far have been in any trouble during any of our manned testing.

Prior to running a manned profile, we always test the centrifuge to one and a half times the g level that the man will be subjected to. This is a safety measure to make sure that everything in the gondola is secure and that the restraint systems will support the necessary loading. To prepare for a test run may take as long as two months, although a normal test requires about two weeks of preparation time.