63-4-1

FINAL REPORT

SIMULATION OF CABLE PRESSURIZATION

WING I - MINUTEMAN

MTOR-C-170
28 March 1963

Prepared for:

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SEATTLE, WASHINGTON

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Under:

P.O. 2-706320
CONTRACT AF04(647)-289

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LIST OF ILLUSTRATIONS

5. It is recommended that the following items be implemented to insure a satisfactory cable pressure system in Wings II to V:

   A. A program for the continued use and verification of the cable simulators to include:

      1 - Verification and perfection of the simulation technique

      2 - Use of the simulators as a tool for familiarization of maintenance personnel with the pneumatic behavior of the cable network.

      3 - Study use of the simulators as a fault location aid.

      4 - Study integration of the simulators into the cable system maintenance concepts.

      5 - Simulate Wings 2 to 5 on the "Universal Simulator".

   B. Collection, reduction and analysis of existing data on the Wing I cable system for verification of the simulation techniques.

   C. Integrated pressure system study to establish all pneumatic parameters based on the simulation results and field data.

6. A comprehensive review of the current maintenance concepts to drastically reduce the scheduled and non-scheduled maintenance costs for the pressurization system.

Simulation of Cable Pressurization

Wing I - Minuteman

1.0 Introduction

This report describes a study of the pressurization system for the buried cable network of Wing I, Minuteman. The purposes of this study follow:

a. To determine expected pressure distribution throughout the buried cable network of Wing I using various pressurization inputs and leakage rates.

b. To determine airflow from the compressors used for pressurization of the buried cable network, using various pressurization inputs and leakage rates.

c. To form conclusions and recommendations based on the information determined in a and b above.

The objectives of the study were to:

a. Determine the expected pressure distribution in the cable network. This would provide a standard for judging the quality of the aotual buried cable installation. A variation in pressure throughout the buried cable installation is expected. Some means is necessary for determining whether this pressure distribution is normal (i.e. due to the pneumatic characteristics of the cable network) or if there is a fault in the cable installation.

b. Determine the number and location of compressors needed to maintain the cable network at a desirable pressure level.

c. Determine the capacity (airflow) requirements of the compressors used to maintain network pressure.

d. Furnish information about the pressurized cable network on which the design adequacy of the buried cable system could be judged.

2.0 Pneumatic Simulation

The study was conducted by means of analog simulation. An electrical model of the Wing I buried cable network was built, in which the electrical properties were analogous to the pneumatic properties of the buried cable network. This electrical model was used to obtain the pneumatic parameters of the buried cable network.

Analysis of the problems of pressure distribution calculations indicated that a purely theoretical approach would be undesirable. While a separate pressurized cable (not part of a network) can be handled theoretically, there is no simple method for analyzing pneumatic conditions in a complex network of interconnected cables such as is used in Wing I. Theoretical calculations for a network of cables are extremely cumbersome and time-consuming. Moreover, these calculations are useful only for one specific set of pneumatic conditions; for each different set of conditions (e.g. a different pressurization configuration and/or leakage rate) an entirely new calculation would have to be made. New calculations would also have to be made if there were any change in the configuration of the buried cable network.

It was decided to conduct the study by simulation, using an electrical model in which the pneumatic parameters of the pressurized cable system are represented by analogous electrical parameters.

3.0 Theory of Simulation

The relation of airflow through a cable to pressure drop can be approximated by an ohm's-law relationship: (See document MTOR-C-052 Final Report: Buried Cable Design Verification Program, Page III-47)

$$\text{Pneumatic Resistance} = \frac{\text{Pressure Drop}}{\text{Air Flow}}$$

Although this relationship is not exact (pneumatic resistance varies with input pressure) the variation is not large enough in the pressure range under consideration to introduce appreciable error. This permits an electrical analogy; pressure is represented by voltage, pneumatic resistance is represented by electrical resistance, and airflow is represented by current.

Air leaks from the cable mainly at the splice cases (see MTOR-C-052 page III-14). The leakage at each splice case can be represented as an electrical conductance to ground. A run of cable consisting of several lengths of cable spliced together (Figure 1) can be represented by the electrical analog shown in Figure 2.

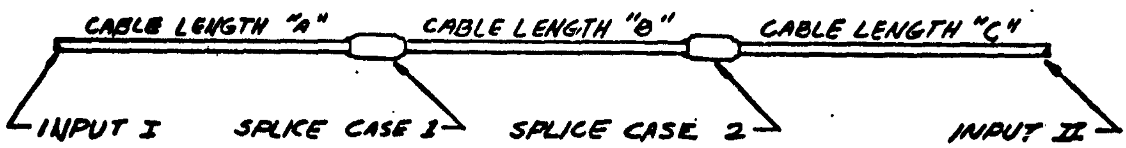


Figure 1. A Run of Pressurized Cable

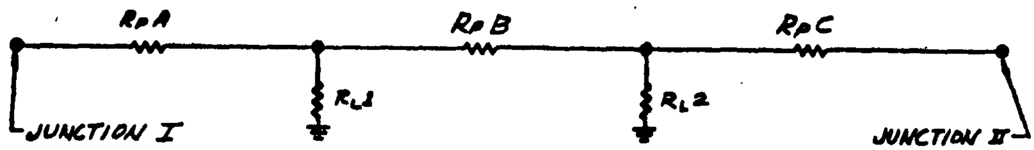


Figure 2. Electrical Analog of Pneumatic Characteristics of Pressurized Cable Shown in Figure 1.

In the electrical model shown above, resistors R_pA, R_pB, and R_pC represent the pneumatic resistance of cable lengths A, B, and C respectively. Resistors R_L1, and R_L2 are electrical conductances representing the pneumatic leakage at splice cases 1 and 2 respectively. Voltages applied at junctions I and II represent the pressure applied at inputs I and II respectively. A measurement of voltage or current at any point on the electrical model indicates the pressure or airflow at the corresponding point in the pneumatic cable run.

The resistors in Figure 2 can be lumped together to form a simple Tee (see Figure 3).

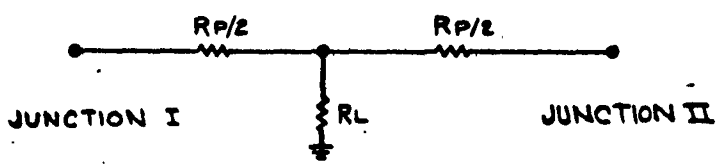


Figure 3. Lumped Tee

In the lumped Tee, each series resistor $R_p/2$ represents one half of the total pneumatic resistance ($R_p = R_pA + R_pB + R_pC$) of the cable. The shunt, R_L represents the total leakage conductance $\left(\text{Conductance}_{RL} = \text{Conductance}_{RL_1} + \text{Conductance}_{RL_2} \text{ or } \frac{1}{RL} = \frac{1}{RL_1} + \frac{1}{RL_2}\right)$.

Calculations show that the Tee in Figure 3 has almost the same impedance as the circuit in Figure 2, with only a negligible error (see TMR 947.1, page 4). A cable network simulator can be built in which each cable length between two junction points is represented by a simple Tee network; the Tees being connected together in the same configuration as the cable lengths in the actual buried cable network. Figure 4 is one example of cable network. Figure 5 is the electrical simulation of the cable network in Figure 4. The series and shunt resistors of each Tee in Figure 5 have values which represent, respectively, the pneumatic resistance and leakage conductance of the corresponding cable in Figure 4. Compressor inputs are represented by voltage supplies with values representing the pressure furnished by each compressor. Pressure at any junction in the cable network is found by measuring the voltage at the corresponding point in the simulator. Airflow is found by measuring the current at any point in the simulator.

4.0 Pneumatic Values and Electrical Equivalents

A. Pneumatic Resistance, R_p. The pneumatic resistance of a cable is the ratio of pressure drop to air flow. The dimensions of pneumatic resistance are:

$$\frac{\text{pounds per square inch}}{\text{cubic feet per hour}}, \text{ or } \frac{\text{psi}}{\text{cfh}} .$$

Physical measurements of pneumatic resistance for various cable sizes had been made previously. The R_p values of Wing I cables were based on these measurements (see Appendix I). R_p, in $\frac{\text{psi}}{\text{cfh}}$, is represented in simulation on the basis of 10 ohms = 1 $\frac{\text{psi}}{\text{cfh}}$. R_p is represented in a Tee by two series resistors, each of which has the value $R_p/2$.

B. Leakage Conductance. The leakage conductance of a cable is the ratio of total cable air leakage to average gauge pressure in the cable. The dimensions of leakage conductance are:

$$\frac{\text{cubic feet per hour}}{\text{pounds per square inch}}, \text{ or } \frac{\text{cfh}}{\text{psi}}.$$

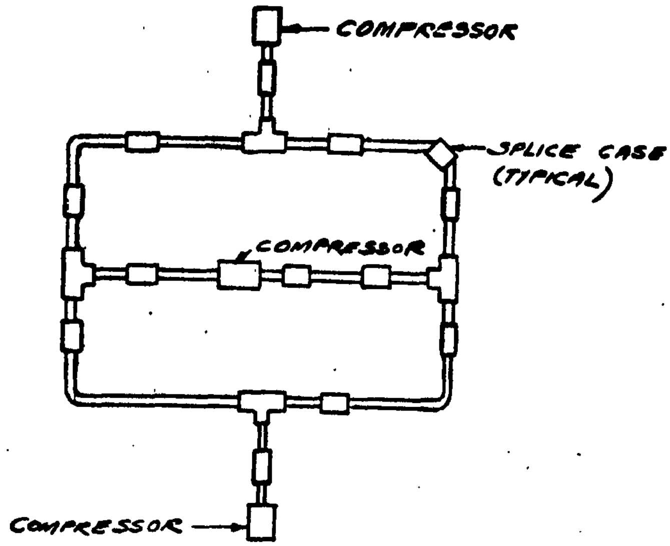


Figure 4. Pneumatic Cable Network

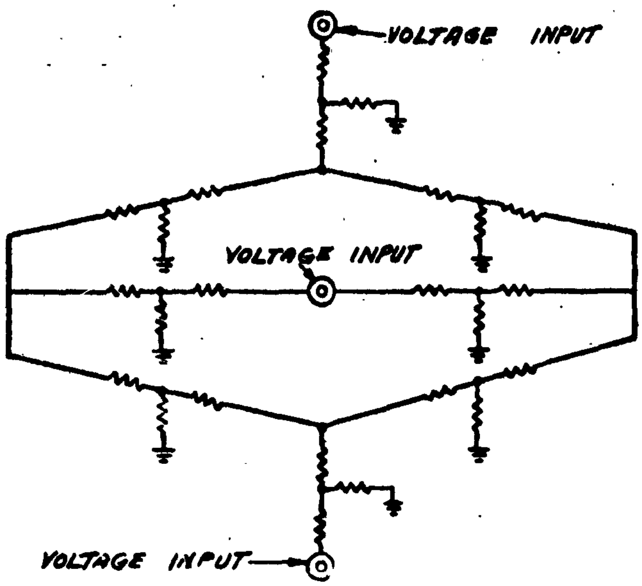


Figure 5. Electrical Model for Network Shown in Figure 4.

Cable air leakage occurs principally at the splice cases, and is considered independent of the size (cross-section) of the cable. Since there are splice cases at regular intervals (2 to 3 per mile), leakage conductance can be treated as a function of cable length only. The value of leakage depends on the quality of the splice case installations. However, as explained in TMR-947.1 (page 4) it is reasonable to use a maximum leakage rate of 0.5 cubic feet per day per mile (CFDM) at 10 psig pressurization in the present installation. It is also felt that a leakage rate of 0.1 CFMD with 10 psig pressurization is a reasonable goal for future installations.

For the computation of leakage conductance based on these leakage rates see Appendix I. Leakage conductance is represented in a Tee by R_L, the shunt to ground. Simulation is on the basis of 1 mho = $10 \frac{cfh}{psi}$ (10 ohms = $1 \frac{psi}{cfh}$).

Pressure is represented, in simulation, on the basis of 1 volt = 1 psi, with electrical ground (zero volts) corresponding to atmospheric pressure (zero psig.) Since 1 volt = 1 psi, and 10 ohms = $1 \frac{psi}{cfh}$, air flow is represented on the basis of 1 amp = 10 cfh.

5.0 Simulator Panels

Each of the 15 flights comprising Wing I was simulated on a separate panel, called a flight simulator panel (Figure 6 is a photograph of a group of 6 flight simulator panels.)

The flight simulator panels were designed primarily for making the simulation study of cable pressurization.

It was felt that when the study was concluded, the simulator panels would still be useful as field maintenance tools. For this reason, the simulator panels were packaged for portability. The simulator electrical network was laid out in a maplike fashion and suitably labelled on the front of the simulator panel to permit easy correlation between simulator display and a flight map of the same flight. The simulator panels were designed to be self-contained, each with its own regulated power supply and meter. Provision for simulation of cable faults (leaks and blockages) was made.

On the flight simulator panel, each cable length is implemented by a "cable group" (see figure 7). The resistive tee representing the cable is implemented by three variable resistors in the cable group. These are adjusted to the proper value with an

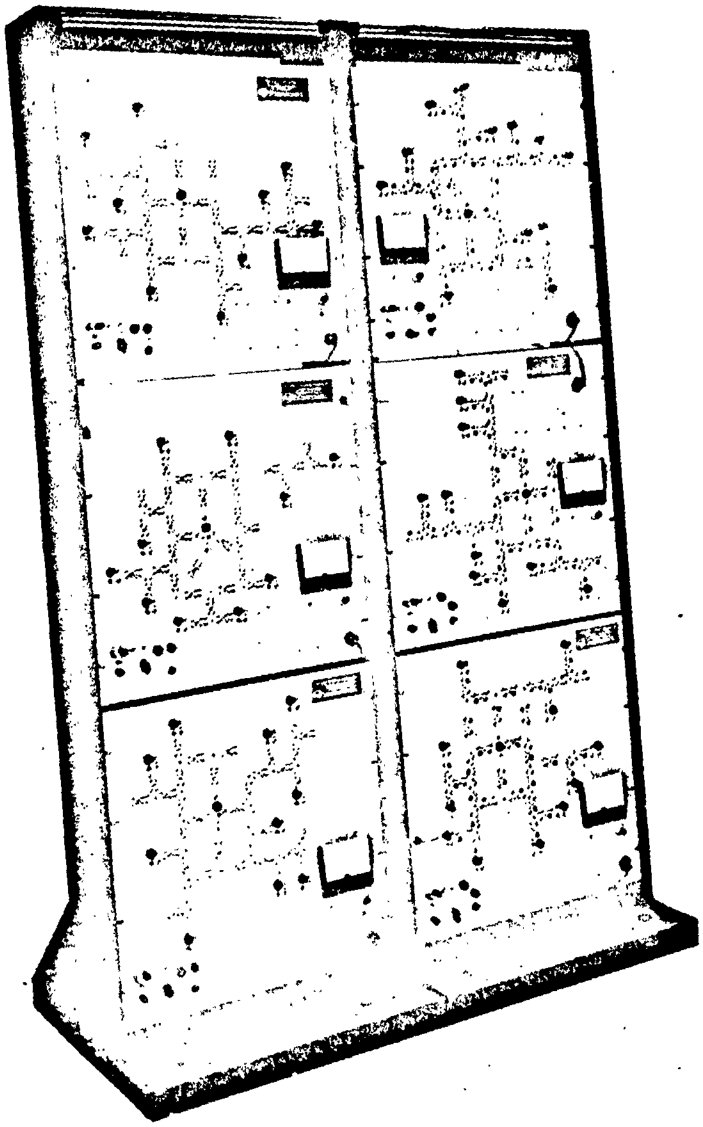
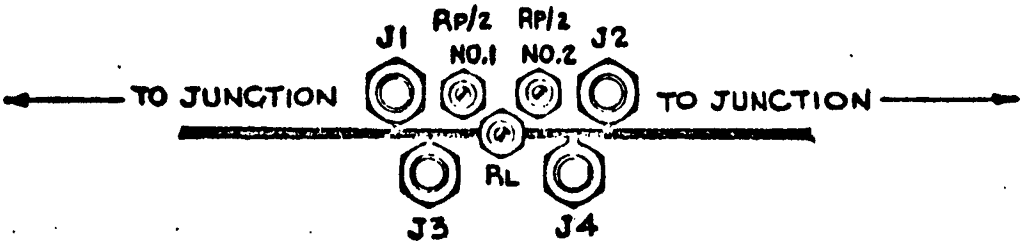
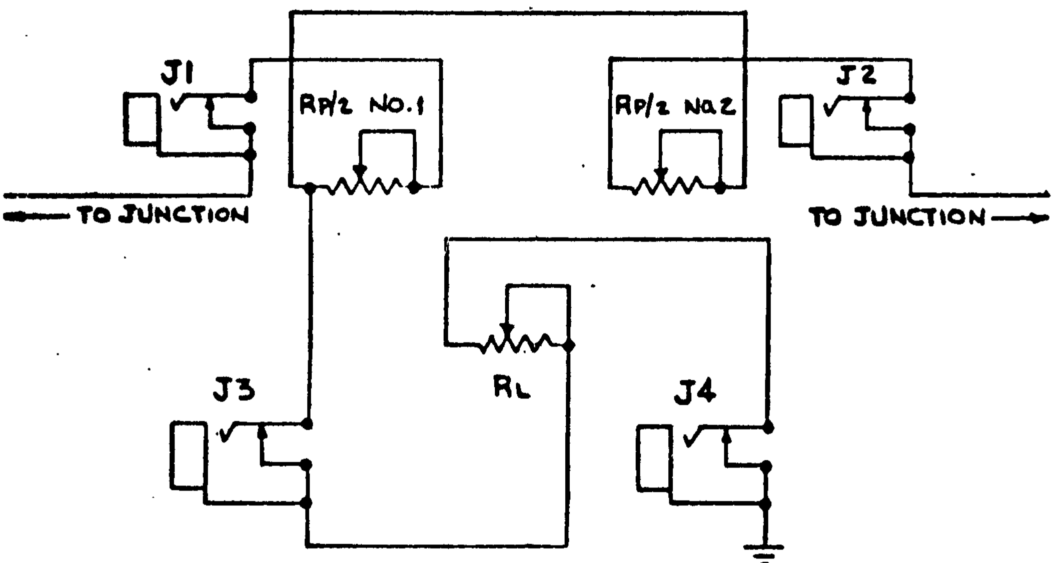


Figure 6. A Group of Six Flight Simulator Panels



7a. Detail View of Cable Group as seen on Flight Simulator Panel.



7b. Schematic Diagram of Cable Group.

Figure 7. Cable Group

external resistance bridge. Jacks for making voltage, current, and resistance measurements are also provided (see figure 7). Referring to the designations in figure 7, the following measurements can be made:

Measurement	How Measured
Resistance of $R_p/2$ No. 1	Plugs inserted in J1 and J3. Measure between tip of J1 and tip of J3.
Resistance of $R_p/2$ No. 2	Plugs inserted in J2 and J3. Measure between tip of J2 and tip of J3.
Resistance of R_L.	Plug inserted in J3. Measure between sleeve of J3 and panel ground.
Current entering cable at left.	Plug inserted in J1; ammeter between tip and sleeve of plug.
Current entering cable at right.	Plug inserted in J2; ammeter between tip and sleeve of plug.

In addition to the above measurements, the jacks permit other functions:

Function	How Performed
Increase R_L beyond value of R_L variable resistor.	Plug inserted into J4, with resistance of desired value between tip and sleeve of plug.
Simulate small leak in cable.	Plug inserted in J1 (leak at left end of cable) or J2 (leak at right end of cable). Tip and sleeve of plug are common, connected to resistor of appropriate value. Other end of resistor is connected to ground.

Function	How Performed
Simulate large leak in cable.	Plug inserted in J1 or J2 as above. Tip and sleeve of plug are wired to each other and to a jumper to ground.
Simulate small blockage of airflow in cable.	Plug inserted in J1 (block at left end of cable) or J2 (block at right end of cable). Resistor between tip and sleeve of plug.
Simulate complete blockage of airflow in cable.	Plug inserted in J1 or J2 as above. No wiring to plug.

At each cable junction on the flight simulator panel, there is a momentary pushbutton which connects the junction to a voltmeter on the panel to measure junction pressure.

The flight simulator panel contains a regulated 10v d-c power supply, to simulate the 10 psig compressor inputs. The supply has regulation to .08%. A 10v d-c bus carries supply to each LCF and LF group, where it can be applied by throwing a switch.

The LCF and LF groups on the flight simulator panel are shown in figures 8, 9 and 10. Each has a switch, for applying regulated 10v d-c from the regulated power supply, simulating the pressurization from a 10 psig compressor. A lamp next to the switch indicates whether the switch is on. A momentary pushbutton connects the LCF or LF to a voltmeter to measure pressure at the LCF or LF. Each LF group also contains a jack, for the possible connection of an external power supply (simulating a compressor pressure which may be greater or less than 10 psig).

Each flight simulator panel has a voltmeter located on the panel. By use of a switch, the meter can be used to measure voltage (analog of pressure) at any junction, or current (analog of air flow) through any cable. In one position of the meter function switch, the meter operates as part of a resistance-measuring bridge to measure resistive values in the cable Tees.

6.0 Interflight Cables

For constructing each flight simulator panel, an interflight cable (a cable connecting one flight to another) was considered to belong half to one flight and half to

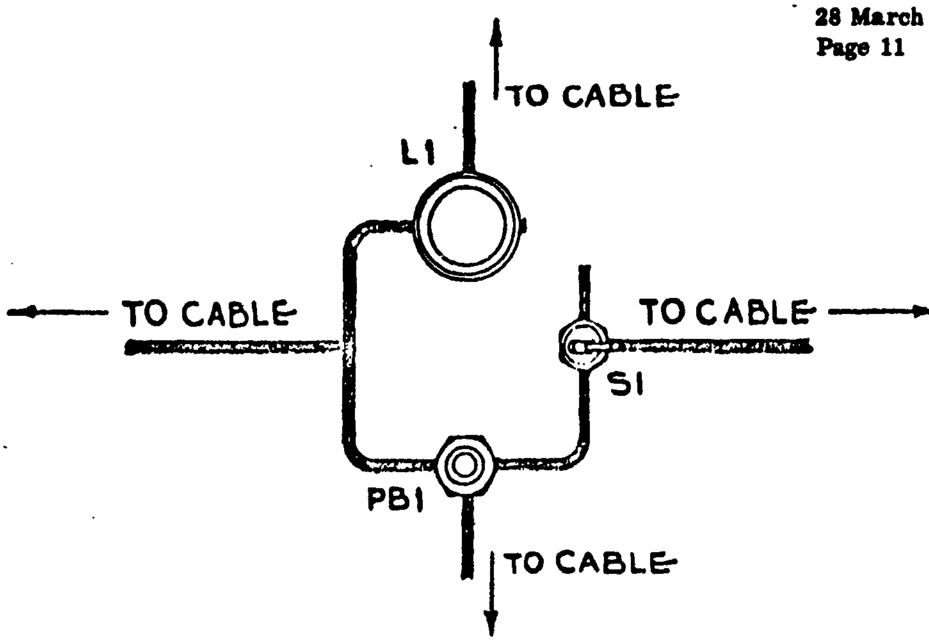


Figure 8. Detail View of LCF Group as seen on Flight Simulator Panel

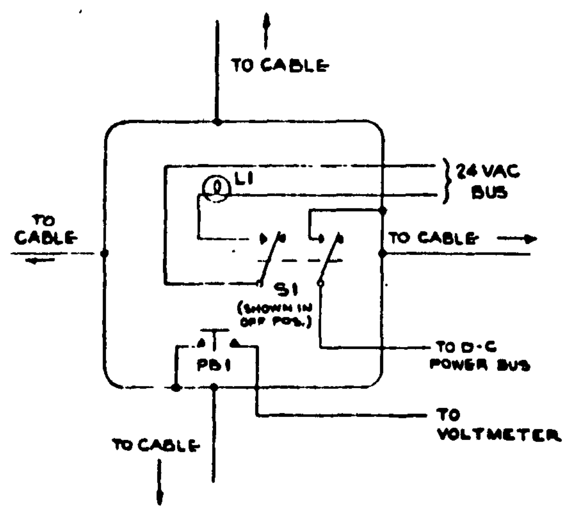
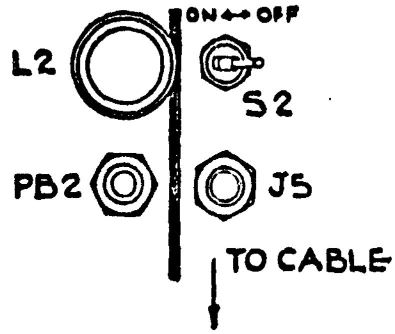
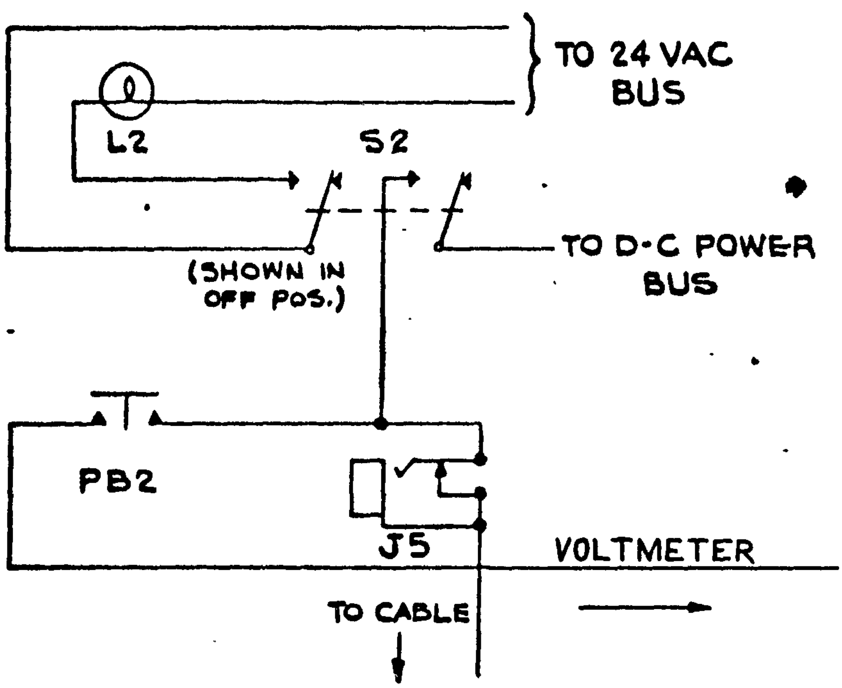


Figure 9. Schematic Diagram of LCF Group



10a. Detail View of LF Group as seen on Flight Simulator Panel



10b. Schematic Diagram of LF Group

Figure 10. LF Group

another. This half-cable was represented on a flight panel by a Tee calculated on the basis of one half the total mileage of the interflight cable.

This method of representing interflight cables allowed simulation to be performed in two different ways:

a. Interconnected Flights: Interflight connections are completed by jumper cables running from one flight panel to another. Each jumper cable joins the outer ends of the two half-tees representing an interflight cable. Thus each interflight cable is represented by the following electrical model:

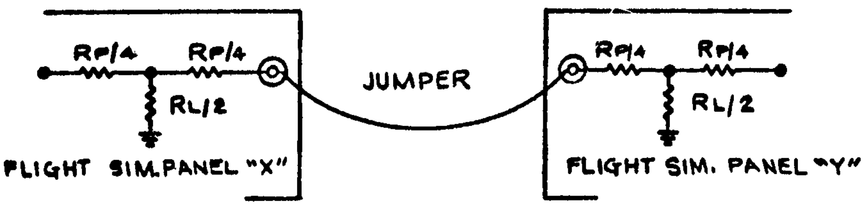


Figure 11. Interflight Cable Electrical Model

whereas an ordinary intraflight cable is represented by this model:

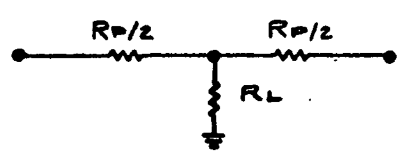


Figure 12. Intraflight Cable Electrical Model (Lumped Tee)

As explained previously, the difference between individual Tee's in series and a lumped Tee of equivalent R_P and R_L is so small that the difference can be ignored. Thus the interconnected-flight simulation accurately represents the cable network of Wing I, Minuteman.

b. Individual Flight Simulation: In this second method of simulation, there are no interconnections between flight panels. The outer end of each half-tee representing half an interflight cable is not connected, but is allowed to float.

The advantage of individual simulation is that it permits the operation of one flight simulator panel without the necessity for the connection, or even the presence, of other flight simulator panels. This is important; the flight simulator panels were built with an eye toward their possible usefulness as field analysis and maintenance aids.

The disadvantage of individual simulation is that it represents the interflight cables by an approximation which does not take into account the pressure difference on the two ends of an interflight cable. The error thus caused in pressure distribution readings is greatest at the interconnection junctions (i.e., the junctions at each end of an interflight cable). The error produced at other junctions is very slight. The amount of error at interconnection junctions for leakage rate of 0.5 CFDM is shown in Table 1, Appendix III. For pressurization at the LCFs only, the error in some individual cases is as great as 0.8 psi, but the average error is only 0.3 psi. For pressurization at the LCFs and all LFs, the error in one case is 0.6 psi; however the average error is only 0.1 psi. Thus each flight simulator panel may be used individually, if it is remembered that readings at the interconnection junctions are only approximate.

The error produced by individual flight simulation at interconnection junctions becomes smaller with any condition that raises minimum system pressure and hence narrows system pressure distribution, such as pressurization at LCFs and all LFs, instead of at LCFs only, or a leakage rate of 0.1 CFDM instead of 0.5 CFDM.

Measurement of pressure distribution at 0.5 CFDM were made with interflight cables connected in this study. Measurement of compressor airflow, and measurement of pressure distribution at 0.1 CFDM, were made by individual flight simulation. To determine whether the error caused by individual flight simulation would affect compressor airflow readings, airflow through interflight cables was measured during the simulation with all flights interconnected. The greatest airflow through an interflight cable was found to be 0.25 cfh, with the average value much lower than this. Since the capacity of an LF compressor is 25 cfh, and since (as will be shown) none of the compressors is operating anywhere near full load, the additional airflow required to feed the interflight cables can be ignored.

7.0 Simulation Data

The following data were determined in this study: The compressor output, where present, is 10 psig.

7.1 Pressure Distribution - With a given leakage rate and a given pressurization configuration, pressure readings at each junction and LF were made. The readings are presented in Figures 13-16. The readings were taken under these conditions:

a. Leakage rate 0.5 CFDM, pressurization at LCFs only (figures 13A through 13-O).

b. Leakage rate 0.5 CFDM, pressurization at LCFs and all LFs (figures 14A through 14-O).

c. Leakage rate 0.1 CFDM, pressurization at LCFs only (figures 15A through 15-O).

d. Leakage rate 0.1 CFDM, pressurization at LCFs and all LFs (figures 16A through 16-O).

Each of the figures 13A through 16-0 is a map of one of the flights in Wing I buried cable network. The letter suffix indicates the flight. For example, figure 13F is a map of flight F.

Figures 13 through 16 serve as a standard for judging the quality of the actual buried cable installation. If the pressure distribution of the actual cable network, with appropriate pressurization, is roughly the same as indicated in figure 13 or 14, then the 0.5 CFDM leakage rate has been achieved. If the pressure distribution in the actual cable network is proportionally lower than indicated in figure 13 or 14, then the system leakage rate is higher than 0.5 CFDM. If the pressure distribution in the actual cable network conforms generally to figures 13 and 14 but with one or two points whose pressure is markedly different than the pressure indicated in figure 13 or 14, a local fault can be suspected.

7.2 Compressor Airflow

With a given leakage rate and a given pressurization configuration, the airflow from each active compressor was measured. Measurements were made for:

a. Leakage rate 0.5 CFDM, pressurization at LCFs only.

b. Leakage rate 0.5 CFDM, pressurization at LCFs and all LFs.

c. Leakage rate 0.1 CFDM, pressurization at LCFs only.

d. Leakage rate 0.1 CFDM, pressurization at LCFs and all LFs.

The measurements are presented in Table I. Each compressor is identified by the name of the facility (LCF or LF) in which it is located, viz, B-1, D-7, H-11, etc.

The airflow at each LCF is broken down into four readings - for example, J1-A, J1-B, J1-C, and J1-D. There is only one compressor at the LCF. But there are four cables from each LCF by which air from this compressor can enter the cable network. If one of these four LCF cables carried a much greater airflow than the others, a block or leakage in this one cable would have a greater impact on network pressure distribution. Thus the airflow from each LCF is broken down to show the airflow through each of the four cables from the LCF. In the example just given, the reading for J1-A shows the airflow from J1 which reaches the network through cable "A", flight J. To identify cable "A" flight J, use the map shown in figure 13-J, 14-J, 15-J, or 16-J. The value J1-total gives the total airflow from the compressor in J-1, and is the sum of the airflows for J1-A, J1-B, J1-C, and J1-D.

7.3 Determination of Minimum Pressurization Needed to Maintain a Certain Minimum Network Pressure:

A study was made of the minimum pressurization needed to maintain various minimum network pressures. With all flight simulator panels interconnected, and all LCFs pressurized, various LF's were pressurized to achieve a certain minimum network pressure with 0.5 CFDM leakage rate. Two rules were followed:

a. No junction or LF in the network could have a pressure less than the minimum network pressure.

b. The number of pressurized LFs should be the minimum number necessary to achieve a., above.

A certain amount of trial and error was necessary to achieve the best solution (that is, minimum number of pressurized LF's). Determinations were made for minimum network pressures of 6 psig, 7 psig, and 8 psig. It was found that some flights could not be brought up to an 8 psig minimum even if all LFs were pressurized. Because of this, the following procedure was used for the 8 psig minimum network pressure:

a. For those flights which could not be brought up to 8 psig, pressurize all LFs and record the minimum pressure value in the flight.

b. For those flights which could be brought up to 8 psig, pressurize only as many LFs as needed to achieve 8 psig in these flights.

7.4 Effect of Interflight Cables.

It is possible to consider the pressurized cable network of Wing I, Minuteman as consisting of 15 separate pressurized networks (the flight networks) whose pressure distributions are modified by airflow from one flight to another through the interflight cables. Because of the small number of interflight cables (from two to five interflight connections per flight) it was felt that the modifying influence exerted by the interflight cables might be relatively small. If this were true, then each flight cable network could be considered as a separate pneumatic system, with a small allowance made for the effects of an interflight cable at its point of connection to the flight cable network.

The comparison of interconnected flight simulation with individual flight simulation (see 6.0 "Interflight Cables", above) provided some indication that interflight cables did not have a strong effect on flight pressure distributions. Individual flight simulation eliminates the connections between flights, but retains the simulation of the interflight cables as sources of air leakage from the flight networks. To fully determine the effect of the interflight cables, it was desired to simulate a Wing I network in which the interflight cables were completely removed as pneumatic paths. The pressure distribution of this simulation was then compared with the pressure distribution of a normal Wing I simulation (interconnected-flight simulation) to determine the effect of the interflight cables.

To simulate the Wing I network with interflight cables removed as pneumatic paths, each half-tee representing half of an interflight cable was electrically disconnected from each of the flight simulator panels. Comparison with the interconnected-flight simulation showed that the effect of the interflight cables was most noticeable at the interconnection junctions (junctions where an interflight cable connects with a flight network), and only slightly noticeable at other junctions. Recorded measurements were therefore confined to the interconnection junctions.

The results are shown in Table III. For each interconnection junction, this table shows the pressure with all interflight cables removed and with all interflight cables connected. The difference between the two readings shows the effect of interflight cabling on the pneumatic network.

Reading were taken with LCFs only pressurized, and with LCFs and all LFs pressurized. Readings were made only at the leakage rate of 0.5 CFDM, at which leakage rate network pressure differences are greater and the effect of interflight cables more pronounced.

8.0 Analysis of Data:

8.1 Pressure Distribution:

To evaluate the suitability of the pressure distribution values determined by this report, the following criteria are used:

a. A pressure of 4 psig is required to prevent the entry of water into the buried cable network (assumes a possible 8 foot head of water).

b. The warning pressure level (pressure contactor setting) should be at least 2 psi above the water-entry pressure, to allow time after receipt of a warning in which to perform maintenance. Thus the warning pressure, or pressure contactor setting, is 6 psig.

c. The minimum network pressure should be at least 1.5 psi and preferably 2.0 psi above the contactor setting, to avoid alarms caused by temperature and atmospheric fluctuations and tolerance variation of the pressure contactors. Thus the minimum network pressure should be at least 7.5 psig, with a minimum of 8.0 psig preferred.

A maximum leakage rate of 0.5 CFDM, as previously described, is considered a reasonable expectancy for a modern pressurized cable installation. With such a leakage rate, and pressurization at the LCF's only, figures 13A through 13-0 show that a large portion of Wing I will be below the 6 psig warning pressure, with some points as low as 2 psig. This is clearly undesirable.

Table II shows that in order to maintain Wing I merely at the 6 psig warning pressure level with 0.5 CFDM leakage rate, it would be necessary to pressurize an average of four LFs in each flight.

Table II and figure 11 show that it is impossible to attain the desired 8 psig minimum network pressure with 0.5 CFDM leakage rate, even if all LF's are pressurized. However, as seen in Table II, a 7.4 psig minimum network pressure can be attained with 0.5 CFDM leakage rate by pressurizing an average of 8 LF's in each flight. This is just barely acceptable. In order to avoid confusion as to which LF is pressurized and which is not, and to supply a certain safety factor to the system, it is recommended that all LFs in Wing I be pressurized for an 0.5 CFDM leakage rate. This would result in a minimum network pressure of 7.4 psig (pressure distribution shown in figures 14-A through 14-0).

It is also recommended that strenuous efforts be undertaken to reduce the leakage rate below 0.5 CFDM. Reduction of leakage rate would cause a noticeable improvement in minimum network pressure. For example, with 0.5 CFDM leakage rate and pressurization at LCFs only, the minimum network pressure is 2.0 psig; with 0.1 CFDM leakage rate and pressurization at LCFs only, the minimum network pressure is 6.4 psig. With 0.5 CFDM leakage rate and pressurization at all LCFs and LFs, minimum network pressure is 7.4 psig. With 0.1 CFDM leakage rate and pressurization at all LCFs and LFs, minimum network pressure is 9.4 psig.

8.2 Compressor Capacity

The LCF compressors have a capacity of 208 cfh; those at the LFs have a capacity of 25 cfh. As shown in Table I, the actual airflow from these compressors, with 0.5 CFDM leakage rate, is far below the capacity of the compressors (order of magnitude, capacity to actual output is about 100:1).

Thus the compressors are more than adequate for their job.

8.3 Effect of Interflight Cables

Table III shows that the maximum difference in pressure due to the presence of interflight cables is 2.9 psi. This is with LCFs only pressurized and a leakage rate of 0.5 CFDM.

This amount is sufficiently large that the effect of interflight cables must definitely be considered in cable network analysis. Note, however, that with LCFs only pressurized and 0.5 CFDM leakage the average difference in pressure at interconnection junctions is only 0.7 psi. As previously stated, the difference in pressure at junctions other than interconnection junctions is so slight as not to be worth recording. This suggests that the effect of interflight cables need only be considered at those junctions where Table III shows such effect to be considerable.

Recall, also, that it is recommended that if an 0.5 CFDM leakage rate is achieved, then the Wing I network should be operated with all LCFs and LFs pressurized. Under such conditions, Table III shows that the maximum difference in pressure due to the presence of interflight cables is 0.7 psi, and the average difference at interconnection junctions is 0.3 psi. Thus, with 0.5 CFDM leakage, and all LCFs and LFs pressurized, the interflight cables have only a slight effect on the pressure distribution of the Wing I cable network.

9.0 Usefulness of Flight Simulation Panels

In the course of this study a tremendous amount of experience was acquired in the operation of the flight simulation panels. The flight simulation panels were found to have three areas of usefulness:

a. They made possible the study described in this report, furnishing a prediction of the Minuteman buried cable network.

b. They are adaptable to changes in the cable network and to changes in the assumptions made about the pneumatic properties of the cable, and thus can serve to keep the simulation study up-to-date in the face of changing information.

c. They show great potential as fault-location tools, a potential which should be verified by actual field investigation.

As for their usefulness in the present study, it became clear in early investigations of network pneumatic conditions that there was no intuitive way of estimating network pressure and airflow. This was confirmed when pressure distributions were determined which could not have been predicted by any process of logical mental analysis. Also, as explained, there was no feasible method of theoretical calculation which could be used to determine network pressure and airflow.

This very usefulness suggests that employment of the flight simulator panels should not terminate with the present study. The predictions of network pressure and airflow presented in this report are necessarily applicable to a narrow set of conditions. If these conditions were to change, the flight simulator panels could be adjusted and new predictions of network pressure and airflow made quickly and easily by simulation. Possible changes in conditions are:

a. Field experience indicating a change in the assumed leakage rate.

b. Field experience indicating a change in specific pneumatic resistance for some or all of the cable sizes under consideration.

c. A discovery that a value of cable mileage reported for use in this study is incorrect.

d. A decision to alter the geographical path of a cable with a consequent change in cable length.

e. A decision to alter network configuration by adding or deleting a cable in the network.

Each of these changes could be represented by appropriate modification of the flight simulator panels. A change in leakage rate, pneumatic resistance, or cable length would be met by adjustment of the variable resistors comprising the resistive Tees in simulator network - the amount of adjustment would be calculated on the basis described in Appendix I of this report. The deletion of a cable from a flight network would be represented by disconnecting the appropriate resistive Tee from the simulator network - a disconnection which can be accomplished by the insertion of two plugs into the appropriate jacks on the simulator panel. Addition of a cable can be accomplished by adding a resistive Tee consisting of three variable resistors of the proper value. These resistors would probably be mounted on a separate miniature chassis, and connected to the simulator network by patch cords plugging into existing jacks on the simulator panel.

With such simple alterations, the flight simulator panels would continue to furnish predictions of cable network pneumatic properties under a wide variety of changed conditions.

The flight simulator panels also show excellent promise for use in fault location. The use of the simulators as fault-location tools is based on the following circumstances.

a. A fault in the cable network serious enough to have a noticeable effect on the cable network causes a change in network pressure distribution.

b. A reported change in network pressure distribution is considered an indication of fault.

c. It is believed, on the basis of investigation, that the altered pressure distribution caused by a fault is unique for that fault; that the same pressure distribution would not be caused by any other fault.

d. Faults can be simulated on a flight simulator panel.

To use a flight simulator panel as a fault location tool the "fault simulation method" would be employed. A report of actual flight network pressure distribution would be received, and noted to be in disagreement with the predicted pressure distribution. Then various faults would be simulated on a trial and error basis to find a simulated fault which would cause a simulator pressure distribution approximately equal to the actual pressure distribution. The simulated fault would indicate the actual fault.

Since it was not possible to investigate the merit of the fault simulation method by inserting actual faults in an actual cable network, it was decided to use the following method. First, a simulated fault would be inserted into a flight simulation panel, and the altered pressure distribution recorded. Then the fault would be removed. An operator, unaware of the nature and location of the fault, would be given the altered pressure distribution and would try to locate the fault by using the fault simulation method on the same flight simulation panel. It was found that the nature and location of the original fault could be determined rapidly (one or two minutes) and unambiguously by a trial-and-error attempt to find a simulated fault that would produce the altered pressure distribution.

Such investigation is open to criticism, as the flight simulator panel is used as its own validation: first it is pretended that the flight simulator panel is the actual cable network, with a fault included; then it is pretended that the simulator is not the actual cable network, but an analysis device that will function as a fault-locating tool. However, in the absence of an actual cable network available for experimentation, this method is the only one possible, and offers assurance of the following:

a. That a pressure distribution caused by a simulated fault can be duplicated quickly and easily, knowing only the pressure distribution but not the fault.

b. That a pressure distribution caused by a given simulated fault is unique, in that no other simulated fault could cause exactly the same pressure distribution.

Thus the investigation suggests, if it does not confirm, the usefulness of the flight simulator panels for fault location. It is recommended that actual field trials be conducted to investigate this promising possibility of predicting fault location.

TABLE I. COMPRESSOR AIRFLOW

Airflow in cubic feet per hour

Leakage	0.5 CFDM		0.1 CFDM	
Pressurization	LCF Only	LCF and All LF's	LCF Only	LCF and All LF's
FLIGHT A				
A1-DD	.16	.09		
A1-EE	.87	.58		
A1-FF	.17	.12		
A1-GG	.66	.43		
A1-TOTAL	1.87	1.22		
A2		.13		
A3		.19		
A4		.14		
A5		.16		
A6		.09		
A7		.16		
A8		.09		
A9		.10		
A10		.11		
A11		.12		
FLIGHT B				
B1-EE	.15	.07	.04	.02
B1-FF	.32	.14	.09	.03
B1-GG	.44	.20	.10	.04
B1-HH	.42	.16	.11	.03
B1-TOTAL	1.33	.57	.34	.12
B2		.12		.02
B3		.14		.03
B4		.13		.03
B5		.11		.02
B6		.14		.03
B7		.05		.01
B8		.15		.04
B9		.10		.03
B10		.11		.03
B11		.11		.02
FLIGHT C				
C1-EE	.18	.07	.04	.01
C1-FF	.28	.15	.07	.03
C1-GG	.18	.11	.04	.02
C1-HH	.75	.39	.21	.07
C1-TOTAL	1.36	.72	.36	.13
C2		.13		.02
C3		.15		.03
C4		.20		.04
C5		.09		.02
C6		.10		.02
C7		.13		.03
C8		.13		.03
C9		.08		.02
C10		.11		.02
C11		.11		.02
FLIGHT D				
D1-GG	.47	.17	.15	.03
D1-HH	.19	.08	.06	.02
D1-II	.25	.10	.08	.02
D1-JJ	.24	.09	.08	.02
D1-TOTAL	1.15	.44	.37	.09
D2		.14		.03
D3		.21		.04
D4		.11		.02
D5		.16		.03
D6		.15		.03
D7		.16		.04
D8		.22		.06
D9		.16		.03
D10		.16		.03
D11		.14		.03
FLIGHT E				
E1-CC	.33	.15	.11	.03
E1-DD	.18	.10	.06	.02
E1-EE	.21	.11	.07	.02
E1-FF	.22	.10	.07	.02
E1-TOTAL	.94	.46	.31	.09
E2		.10		.02
E3		.11		.03
E4		.14		.03
E5		.10		.02
E6		.11		.02
E7		.12		.03
E8		.20		.04
E9		.18		.03
E10		.14		.03
E11		.17		.04
FLIGHT F				
F1-CC	.16	.07	.05	.02
F1-DD	.23	.11	.08	.02
F1-EE	.42	.20	.13	.04
F1-FF	.45	.21	.14	.04
F1-TOTAL	1.26	.59	.40	.12
F2		.06		.02
F3		.15		.03
F4		.16		.03
F5		.16		.03
F6		.16		.03
F7		.11		.02
F8		.17		.04
F9		.09		.02
F10		.14		.03
F11		.14		.03
FLIGHT G				
G1-A	.19	.07	.05	.01
G1-B	.31	.10	.06	.02
G1-C	.18	.10	.08	.02
G1-D	.48	.16	.14	.03
G1-TOTAL	1.16	.43	.33	.08
G2		.15		.03
G3		.30		.06
G4		.10		.01
G5		.14		.03
G6		.16		.03
G7		.15		.03
G8		.09		.02
G9		.14		.03

TABLE I. (Continued)

Leakage / Pressurization	0.5 CFDM: LCF Only	0.5 CFDM: LCF and All LF's	0.1 CFDM: LCF Only	0.1 CFDM: LCF and All LF's
G10		.16		.03
G11		.14		.03
FLIGHT H				
H1-A	.11	.07	.03	.02
H1-B	.40	.23	.16	.05
H1-C	.39	.20	.13	.04
H1-D	.38	.17	.10	.03
H1-TOTAL	1.37	.67	.42	.14
H2		.17		.03
H3		.18		.03
H4		.16		.04
H5		.17		.03
H6		.15		.03
H7		.09		.02
H8		.09		.02
H9		.17		.04
H10		.25		.05
H11		.15		.03
FLIGHT I				
I1-A	.63	.30	.19	.07
I1-B	.61	.43	.17	.11
I1-C	.18	.10	.04	.03
I1-D	.35	.16	.11	.04
I1-TOTAL	1.74	.99	.51	.25
I2		.09		.03
I3		.08		.02
I4		.12		.03
I5		.16		.04
I6		.13		.03
I7		.15		.04
I8		.16		.04
I9		.11		.03
I10		.32		.06
I11		.18		.04
FLIGHT J				
J1-A	.15	.09	.04	.02
J1-B	.42	.21	.14	.06
J1-C	.44	.20	.13	.04
J1-D	.36	.18	.10	.04
J1-TOTAL	1.37	.68	.41	.15
J2		.09		.02
J3		.13		.03
J4		.12		.02
J5		.14		.04
J6		.15		.03
J7		.20		.05
J8		.16		.04
J9		.12		.03
J10		.12		.03
J11		.14		.03
FLIGHT K				
K1-CC	.64	.26	.15	.04
K1-DD	.23	.10	.05	.02
K1-EE	.34	.16	.06	.03
K1-FF	.12	.08	.06	.01
K1-TOTAL	1.33	.60	.36	.10
K2		.12		.02
K3		.16		.03
K4		.17		.03
K5		.13		.02
K6		.16		.03
K7		.13		.02
K8		.15		.02
K9		.14		.02
K10		.14		.02
K11		.12		.02
FLIGHT L				
L1-EE	.78	.37	.19	.06
L1-FF	.22	.10	.06	.02
L1-GG	.50	.22	.11	.03
L1-HH	.10	.06	.02	.01
L1-TOTAL	1.60	.75	.37	.12
L2		.15		.02
L3		.13		.02
L4		.15		.02
L5		.17		.03
L6		.14		.01
L7		.14		.02
L8		.13		.02
L9		.17		.03
L10		.14		.02
L11		.18		.03
FLIGHT M				
M1-HH	.74	.30	.18	.04
M1-II	.30	.13	.07	.02
M1-JJ	.36	.16	.06	.02
M1-KK	.34	.13	.06	.02
M1-TOTAL	1.74	.68	.41	.10
M2		.26		.04
M3		.15		.02
M4		.17		.02
M5		.14		.02
M6		.11		.02
M7		.16		.03
M8		.19		.03
M9		.20		.04
M10		.12		.02
M11		.15		.02
FLIGHT N				
N1-CC	.15	.08	.03	.01
N1-DD	.50	.22	.12	.04
N1-EE	.18	.09	.05	.02
N1-FF	.42	.19	.11	.03
N1-TOTAL	1.25	.57	.31	.10
N2		.16		.03
N3		.16		.02
N4		.08		.01
N5		.08		.02
N6		.15		.02

TABLE I. (Continued)

Leakage	0.5 CFDM		0.1 CFDM		Leakage	0.5 CFDM		0.1 CFDM	
Pressurization	LCF Only	LCF and All LF's	LCF Only	LCF and All LF's	Pressurization	LCF Only	LCF and All LF's	LCF Only	LCF and All LF's
N7		.14		.03					
N8		.16		.04					
N9		.22		.04					
N10		.12		.02					
N11		.13		.03					
FLIGHT O									
O-1-BB	.19	.09	.06	.02					
O-1-CC	.18	.08	.04	.02					
O-1-DD	.46	.18	.16	.03					
O-1-EE	.48	.21	.15	.04					
O-1-TOTAL	1.26	.56	.39	.11					
O-2		.09		.02					
O-3		.09		.03					
O-4		.08		.02					
O-5		.13		.03					
O-6		.16		.03					
O-7		.15		.03					
O-8		.22		.05					
O-9		.12		.03					
O-10		.11		.02					
O-11		.07		.02					

TABLE II

PRESSURIZATION NEEDED TO MAINTAIN VARIOUS PRESSURE LEVELS

IIa. To maintain a pressure level of 6 psig, 10 psig pressurization input at the following LCF's and LF's is required.

A1,	A5,	A6,	A7,	A8,	A9,	A11	
B1,	B4,	B-10					
C1,	C3,	C5,	C7,	C9			
D1,	D3,	D6,	D7				
E1,	E4,	E5,	E7,	E8	E11		
F1,	F7,	F10,	F11				
G1,	G3,	G7,	G8				
H1,	H4,	H5,	H6,	H7,	H8,	H9,	H10

I1,	I4,	I9		
J1,	J3,	J5,	J6,	J7
K1,	K4,	K7,	K11	
L1,	L5			
M1,	M2,	M8		
N1,	N4,	N5,	N7,	N11
O-1,	O-2,	O-3,	O-11	

IIb. To maintain a pressure level of 7 psig, 10 psig pressurization input at the following LCF's and LF's is required.

A1,	A5,	A6,	A7,	A8,	A9,	A10,	A11		
B1,	B3,	B4,	B10						
C1,	C3,	C5,	C6,	C7,	C8,	C9			
D1,	D3,	D5,	D6,	D7,	D8				
E1,	E2,	E3,	E4,	E5,	E6,	E7,	E8,	E9,	E11
F1,	F2,	F7,	F8,	F9,	F10,	F11			
G1,	G3,	G6,	G7,	G8,	G11				
H1,	H2,	H4,	H5,	H6,	H7,	H8,	H9,	H10	
I1,	I3,	I4,	I9,	I11					
J1,	J2,	J3,	J5,	J6,	J7				
K1,	K4,	K7,	K8,	K11					
L1,	L5,	L6							
M1,	M2,	M3,	M8,	M9,	M10				
N1,	N4,	N5,	N7,	N8,	N11				
O1,	O2,	O3,	O4,	O7,	O11				

TABLE II. (Continued)

IIc. To maintain a pressure level of 8 psig, 10 psig pressurization input at the following LCF's and LF's is required.*

A1,	A2,	A3,	A4,	A5,	A6,	A7,	A8,	A9,	A10,	A11	(7.4 psig)*
B1,	B3,	B4,	B6,	B9,	B10,	B11					
C1,	C2,	C3,	C4,	C5,	C6,	C7,	C8,	C9			
D1,	D3,	D5,	D6,	D7,	D8,	D9,	D11				
E1,	E2,	E3,	E4,	E5,	E6,	E7,	E8,	E9,	E10,	E11	(7.7 psig)
F1,	F2,	F3,	F4,	F7,	F8,	F9,	F10,	F11			
G1,	G3,	G5,	G6,	G7,	G8,	G10,	G11				
H1,	H2,	H3,	H4,	H5,	H6,	H7,	H8,	H9,	H10,	H11	(7.7 psig)
I1,	I2,	I3,	I4,	I5,	I6,	I9,	I11				
J1,	J2,	J3,	J4,	J5,	J6,	J7,	J8,	J9,	J10,	J11	
K1,	K3,	K4,	K5,	K6,	K8,	K9,	K11				
L1,	L5,	L6,	L8,	L11							
M1,	M2,	M3,	M5,	M7,	M8,	M9,	M10				
N1,	N2,	N3,	N4,	N5,	N6,	N7,	N8,	N10,	N11		
O-1,	O-2,	O-3,	O-4,	O-6,	O-7,	O-9,	O-11				

*Note: Even with all LF's pressurized, some flights cannot be raised to an 8 psig pressure level. For such flights, the attainable pressure level is shown in parenthesis in the table above.

TABLE III

EFFECT OF INTERFLIGHT CABLES

Pressure at interconnection junctions, with interflight cables connected and disconnected. Pressure in psig. All readings at 0.5 CFDM leakage rate.

	LCF's Only Pressurized			LCF's and all LF's Pressurized		
Intercon-nection Junction	Interflight Cables Removed	Interflight Cables Connected	Pressure Difference Connected vs. Removed	Interflight Cables Removed	Interflight Cables Connected	Pressure Difference Connected vs. Removed
A14	8.0	6.5	1.5	9.2	8.6	0.6
A16	9.0	8.6	0.4	9.4	9.3	0.1
A92	6.8	6.6	0.2	8.3	7.6	0.7
B17	5.2	5.6	0.4	9.2	8.6	0.2
B18	9.2	8.7	0.5	9.9	9.7	0.2
B30	7.1	7.2	0.1	9.1	8.9	0.2
B38	4.4	4.5	0.1	9.4	9.0	0.4
C32	8.9	8.5	0.4	9.6	9.4	0.2
C56	4.8	4.2	0.6	9.3	8.7	0.6
C93	7.2	*		8.8	*	
D41	5.5	4.6	0.9	8.9	8.8	0.1
D59	5.3	4.4	0.9	9.0	8.6	0.4
D66	4.3	4.1	0.2	9.5	9.1	0.4
D59	2.7	2.2	0.5	8.6	8.1	0.5
E68	2.4	4.7	2.3	8.6	8.7	0.1
E71	4.9	2.0	2.9	9.0	8.7	0.3
F12	7.2	6.5	0.7	9.0	8.7	0.3
F18	7.0	6.4	0.6	8.9	8.8	0.1
G21	6.3	6.3	0	9.2	8.9	0.3
G48	4.4	4.3	0.1	9.7	9.5	0.2

TABLE III. (Continued)

Interconnection Junction	LCF's Only Pressurized			LCF's and all LF's Pressurized		
	Interflight Cables Removed	Interflight Cables Connected	Pressure Difference Connected vs. Removed	Interflight Cables Removed	Interflight Cables Connected	Pressure Difference Connected vs. Removed
H15	6.3	6.2	0.1	9.1	8.7	0.4
H39	6.3	6.6	0.3	9.1	8.9	0.2
I53	5.0	4.4	0.6	9.0	9.2	0.2
I74	5.6	5.9	0.3	9.3	8.6	0.7
I91	8.1	*		8.9	*	
J42	7.4	6.7	0.7	8.9	8.8	0.1
J69	7.0	6.2	0.8	8.7	8.6	0.1
K10	7.2	7.1	0.1	9.1	9.0	0.1
K15	5.4	4.5	0.9	8.9	8.8	0.1
L14	7.7	7.2	0.5	9.2	9.0	0.2
L19	4.0	4.3	0.3	9.3	8.9	0.4
L30	5.0	5.0	0	9.2	8.9	0.3
L36	8.1	7.5	0.6	9.4	9.1	0.3
M33	6.2	5.2	1.0	9.1	8.8	0.3
M38	7.5	7.4	0.1	9.1	9.0	0.1
M46	7.7	7.3	0.4	9.2	9.0	0.2
M55	6.1	5.1	1.0	9.2	9.0	0.2
M94	6.4	*		9.2	*	
N49	3.7	3.9	0.2	9.5	9.3	0.2
N78	6.5	6.1	0.4	8.7	8.7	0
O57	5.0	4.9	0.1	9.3	9.0	0.3
O82	6.1	6.1	0	9.0	8.7	0.3

* Readings not taken

Figure 13A - Flight A

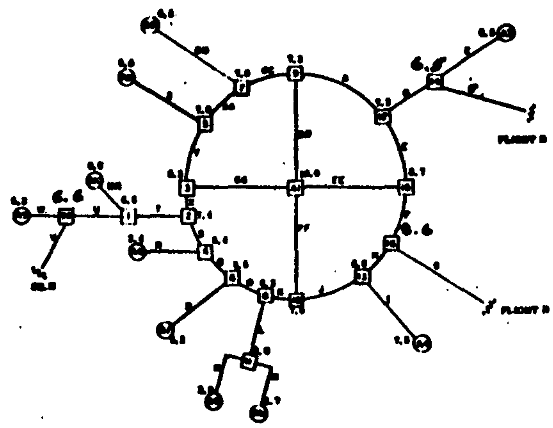
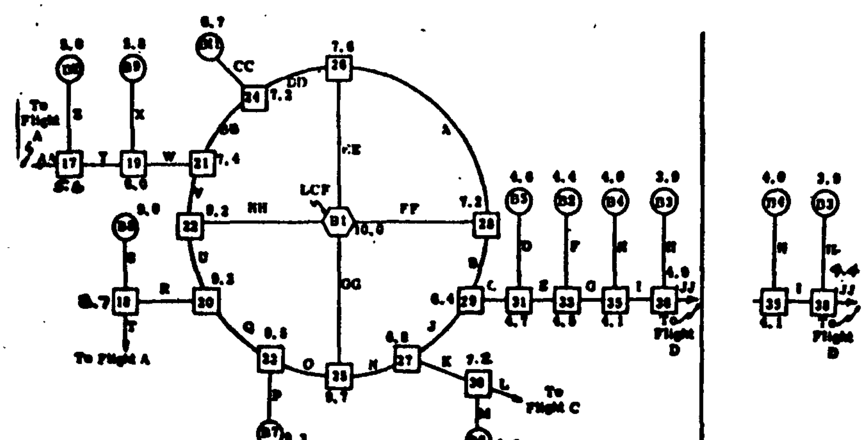


Figure 13B - Flight B



□ Junction Number
○ LF Number
○ LCF Number

Leakage Rate <u>0.5 CFDM</u>
Pressurization Source <u>LCF ONLY</u>

Figure 13 - Pressure Distribution (pressure in psig)

Figure 13C - Flight C

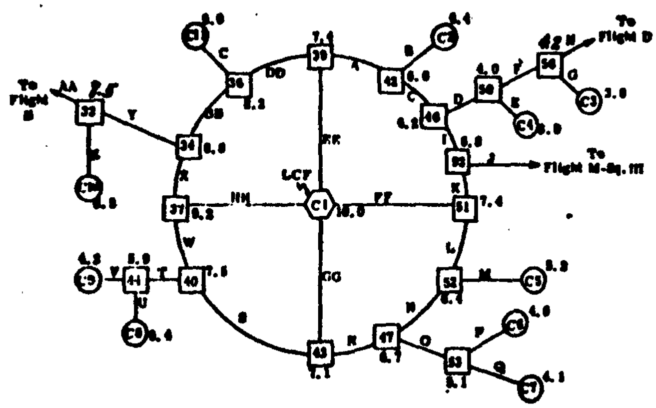
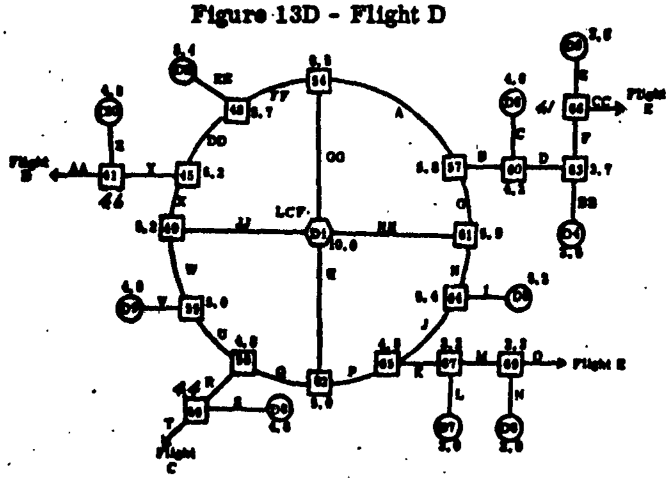


Figure 13D - Flight D



☐ Junction Number
○ LF Number
○ LCF Number

Leakage Rate <u>0.5 CFDM</u>
Pressurization Source <u>LCF ONLY</u>

Figure 13 - Pressure Distribution (pressure in psig)

Figure 13E - Flight E

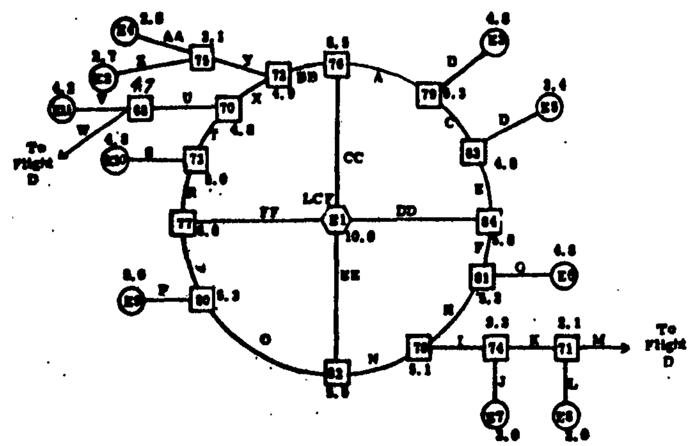
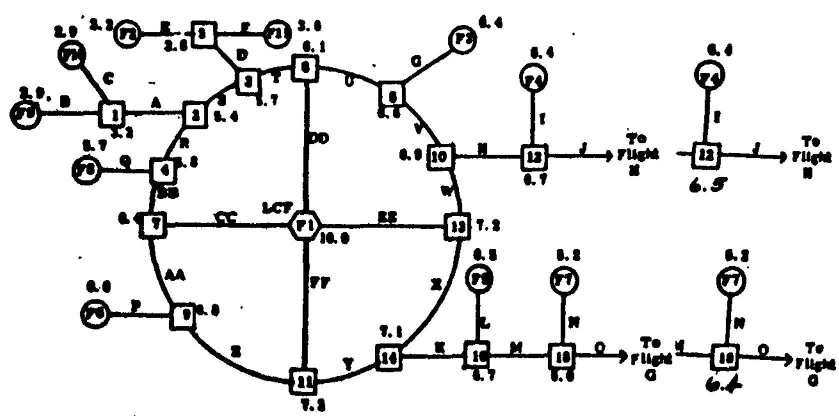


Figure 13F - Flight F



□ Junction Number
○ LF Number
○ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF ONLY

Figure 13 - Pressure Distribution (pressure in psig)

Figure 13G - Flight G

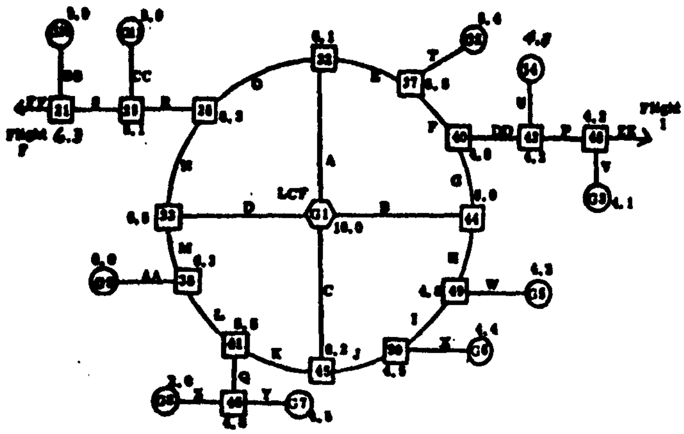
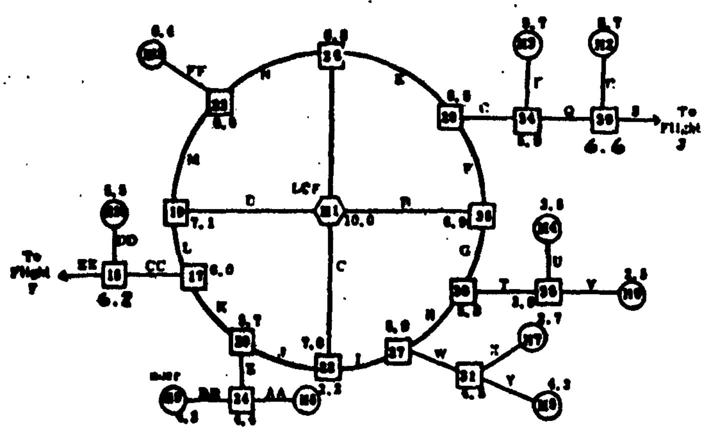


Figure 13H - Flight H



□ Junction Number
○ LF Number
○ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF ONLY

Figure 13 - Pressure Distribution (pressure in psig)

Figure 13 I - Flight I

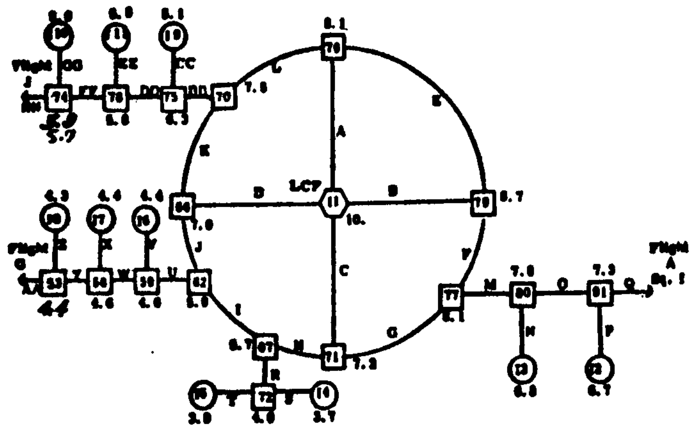
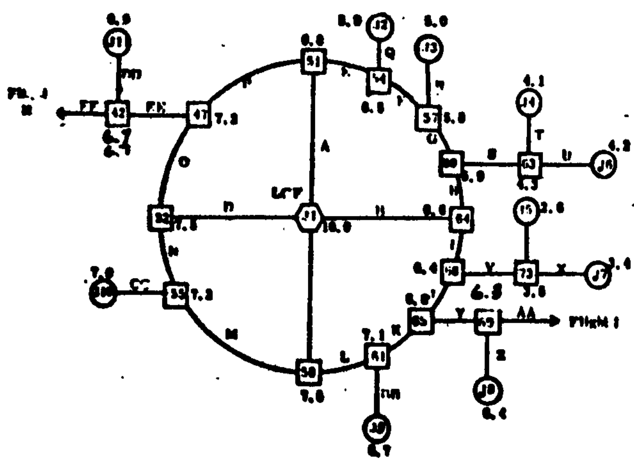


Figure 13J - Flight J



□ Junction Number			
○ LF Number		**Leakage Rate**	**0.5 CFDM**
◯ LCF Number		**Pressurization Source**	**LCF ONLY**

Figure 13 - Pressure Distribution (pressure in psig)

Figure 13K - Flight K

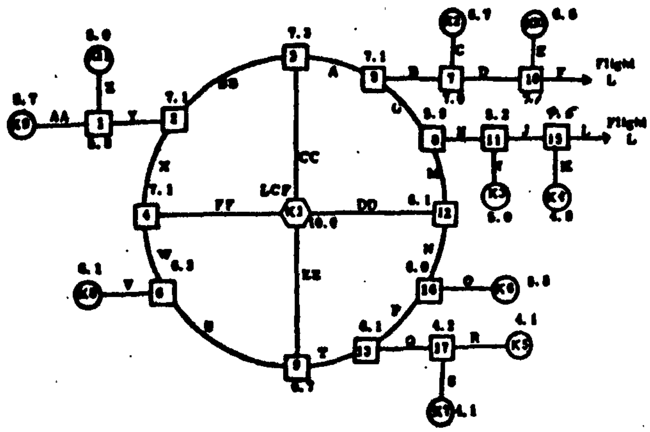
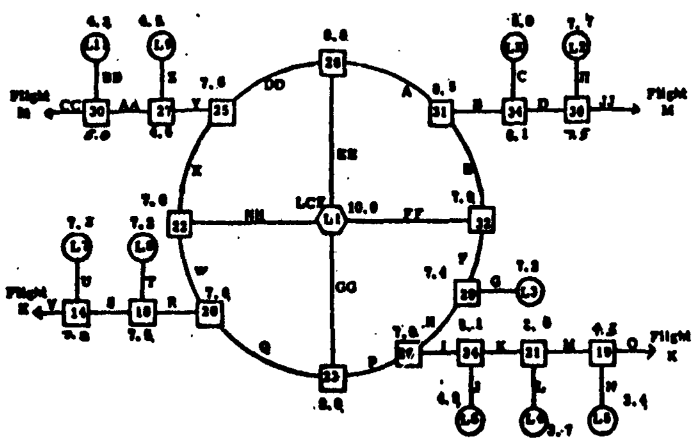


Figure 13L - Flight L



☐ Junction Number
○ LF Number
⬡ LCF Number

Leakage Rate	**0.5 CFDM**
Pressurization Source	**LCF ONLY**

Figure 13 - Pressure Distribution (pressure in psig)

Figure 13M - Flight M

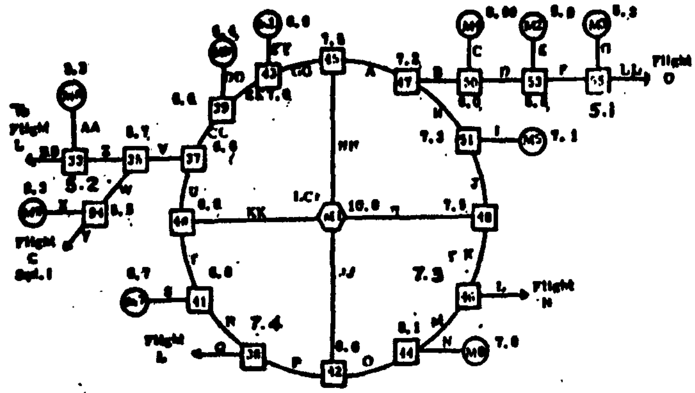
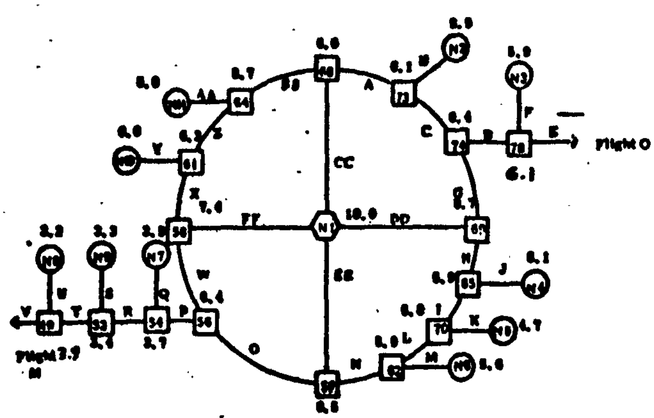


Figure 13N - Flight N



□ Junction Number
○ LF-Number
○ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF ONLY

Figure 13 - Pressure Distribution (pressure in psig)

Figure 13O - Flight O

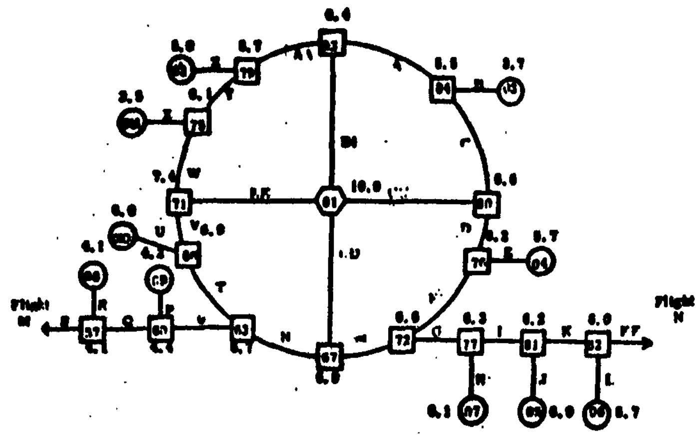


Figure 13 - Pressure Distribution (pressure in psig)

□ Junction Number
○ LF Number
○ LCF Number

Leakage Rate <u>0.5 CFDM</u>
Pressurization Source <u>LCF ONLY</u>

Figure 14A - Flight A

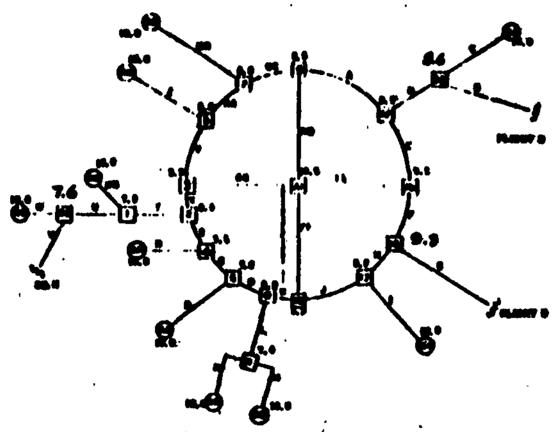
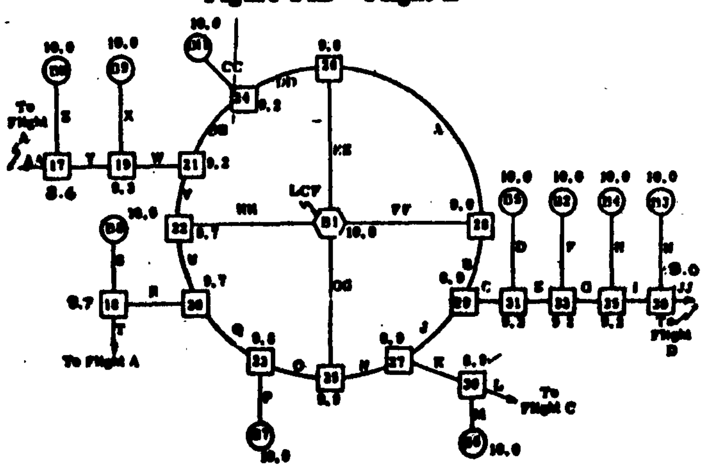


Figure 14B - Flight B



☐ Junction Number
○ LF Number
○ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF AND ALL LF'S

Figure 14 - Pressure Distribution (pressure in psig)

Figure 14C - Flight C

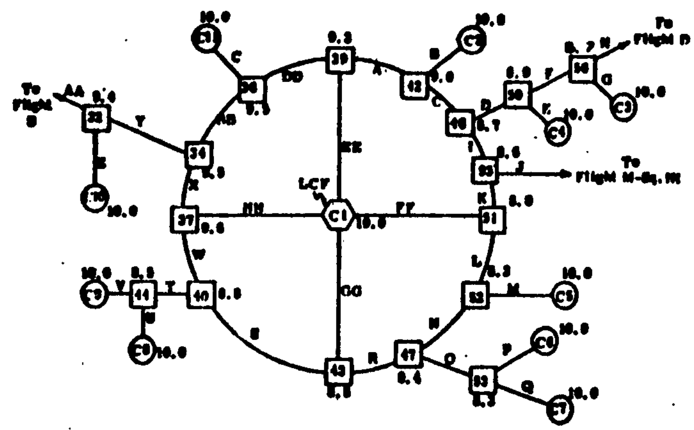
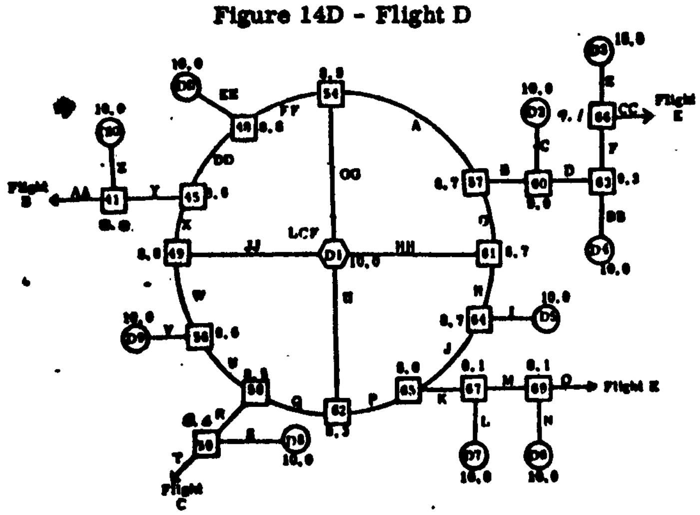


Figure 14D - Flight D



□ Junction Number
○ LF Number
○ LCF Number

Leakage Rate <u>0.5 CFDM</u>
Pressurization Source <u>LCF AND ALL LF'S</u>

Figure 14 - Pressure Distribution (pressure in psig)

Figure 14E - Flight E

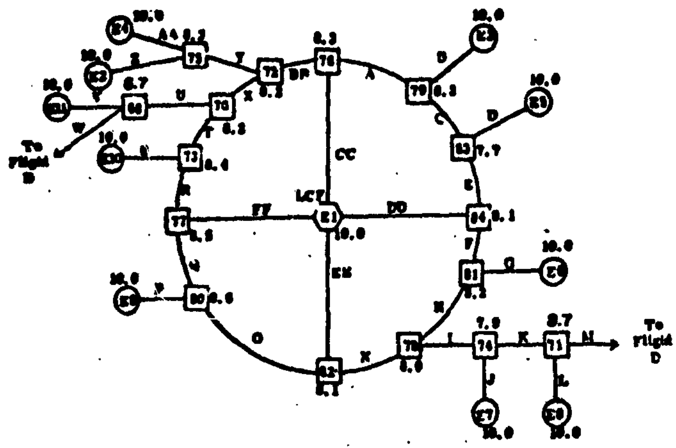
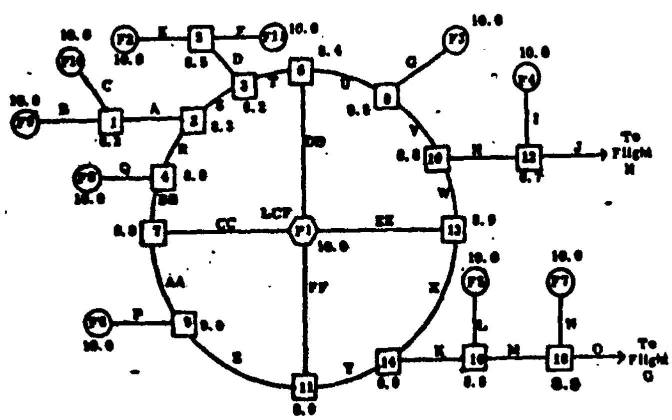


Figure 14F - Flight F



☐ Junction Number
○ LF Number
○ LCF Number

Leakage Rate	0.5 CFDM
Pressurization Source	LCF AND ALL LF'S

Figure 14 - Pressure Distribution (pressure in psig)

Figure 14G - Flight G

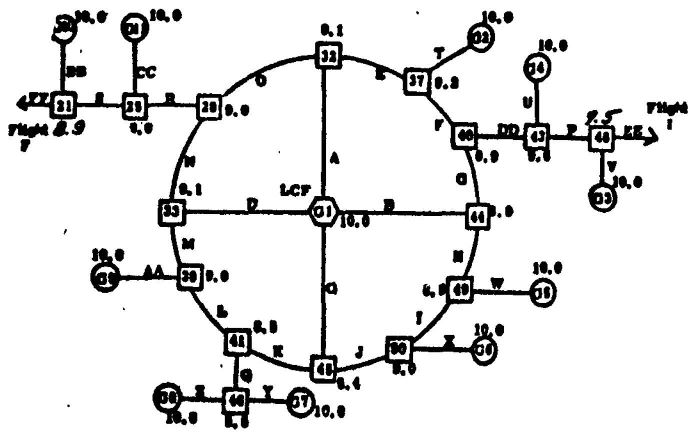
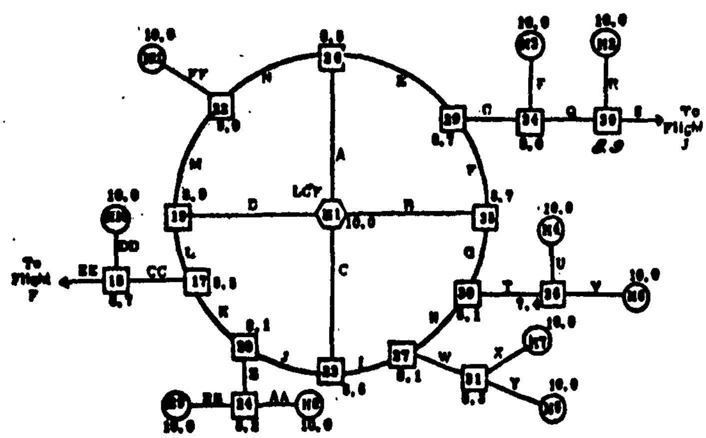


Figure 14H - Flight H



☐ Junction Number
○ LF Number
○ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF AND ALL LF'S

Figure 14 - Pressure Distribution (pressure in psig)

Figure 14I - Flight I

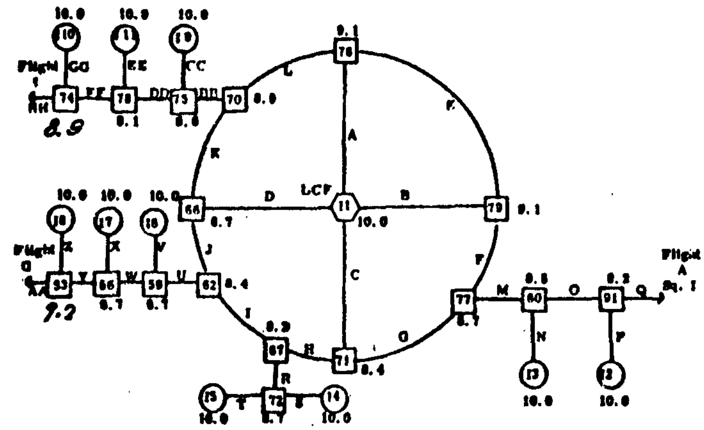
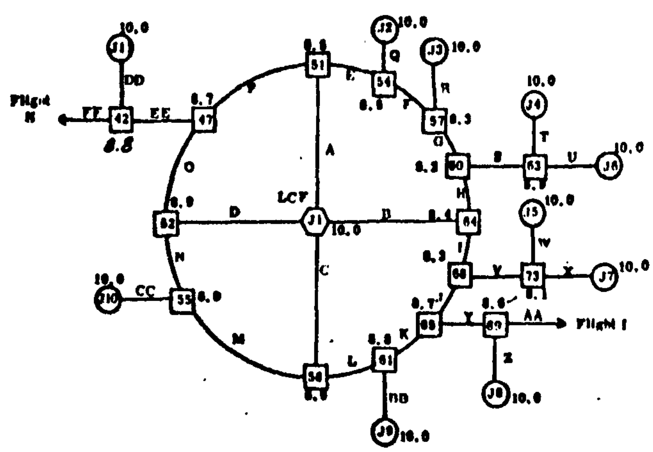


Figure 14J - Flight J



□ Junction Number
○ LF Number
⬡ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF AND ALL LF'S

Figure 14 - Pressure Distribution (pressure in psig)

Figure 14K - Flight K

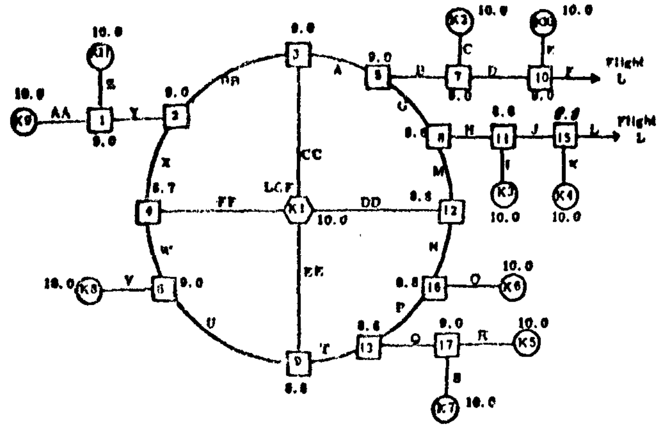
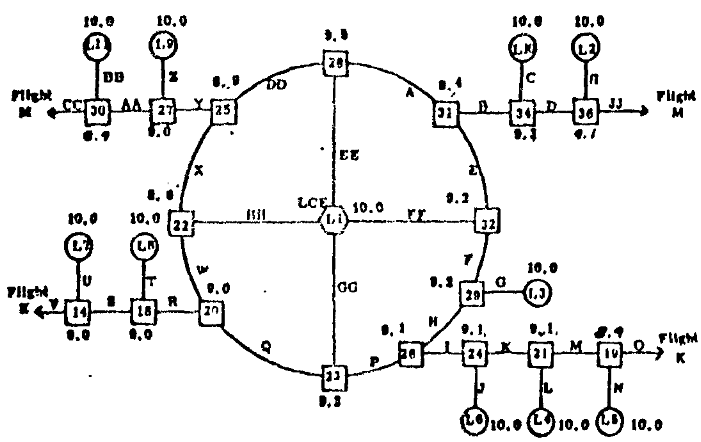


Figure 14L - Flight L



☐ Junction Number
○ LF Number
○ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF AND ALL LF'S

Figure 14 - Pressure Distribution (pressure in psig)

Figure 14M - Flight M

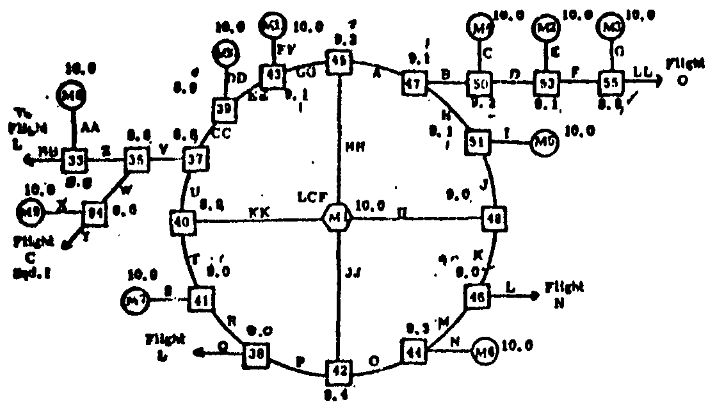
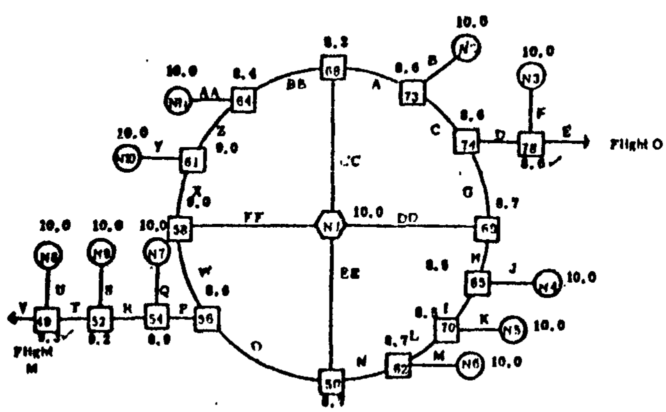


Figure 14N - Flight N

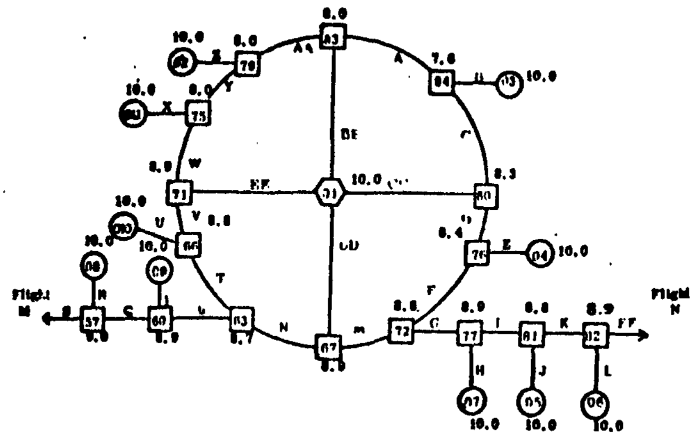


□ Junction Number
O LF Number
O LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF AND ALL LF'S

Figure 14 - Pressure Distribution (pressure in psig)

Figure 14O - Flight O



☐ Junction Number
○ LF Number
○ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF AND ALL LF'S

Figure 14 - Pressure Distribution (pressure in psig)

Figure 15A - Flight A

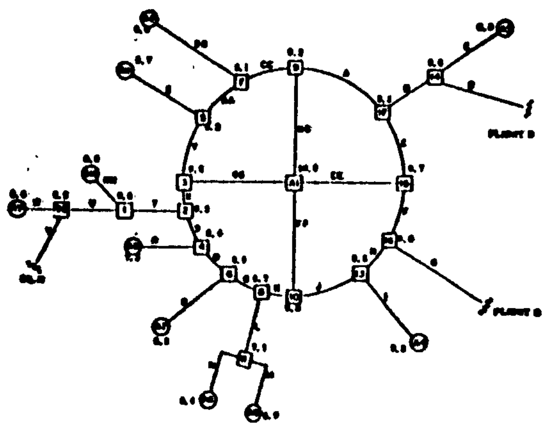
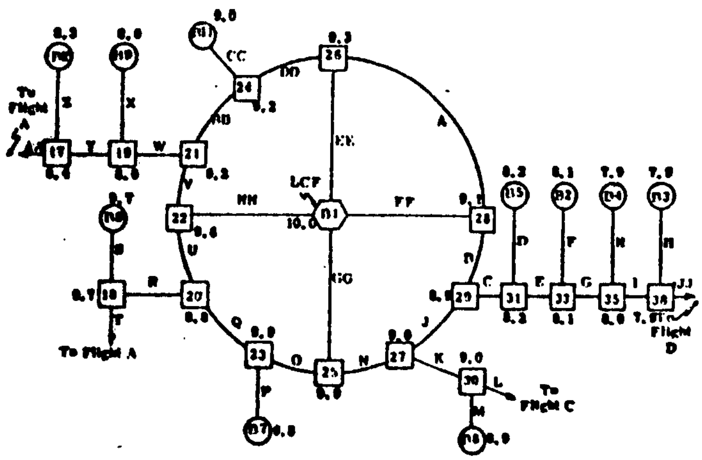


Figure 15B - Flight B



Junction Number
LF Number
LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF ONLY

Figure 15 - Pressure Distribution (pressure in psig)

Figure 15C - Flight C

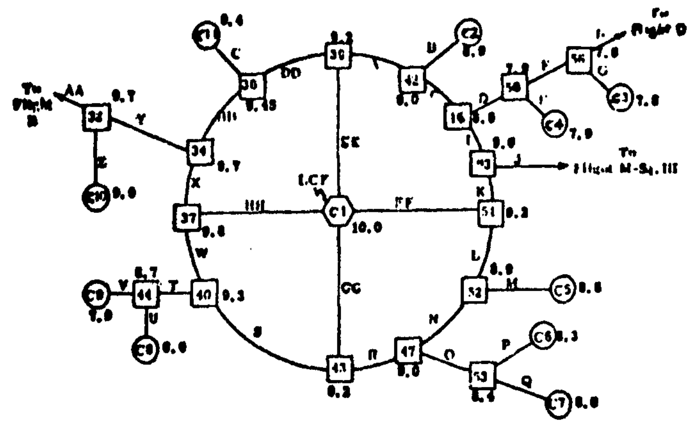
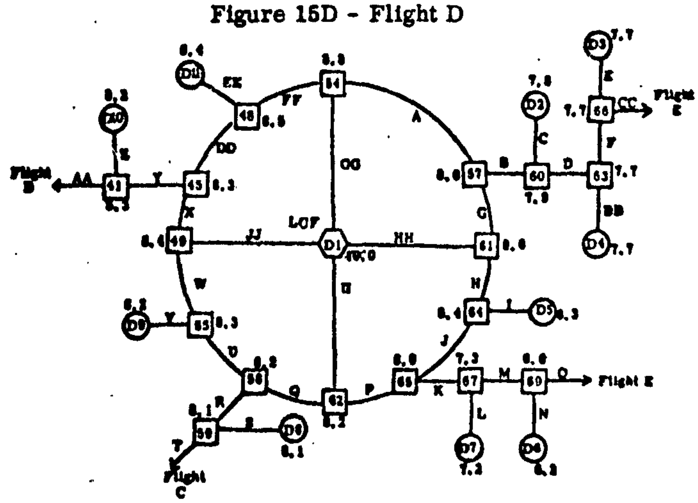


Figure 15D - Flight D



☐ Junction Number
○ LF Number
◯ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF ONLY

Figure 15 - Pressure Distribution (pressure in psig)

Figure 15E - Flight E

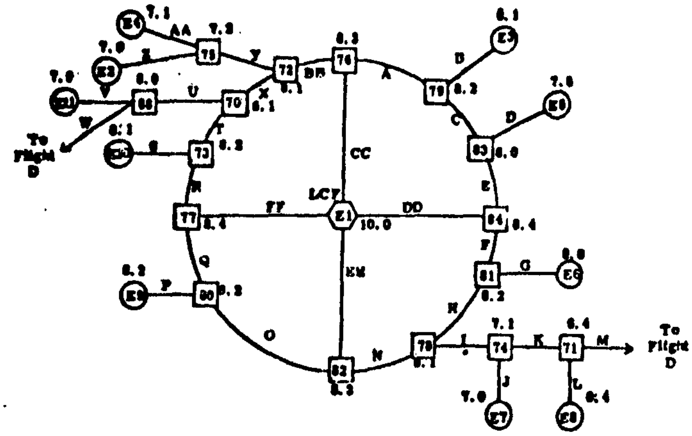
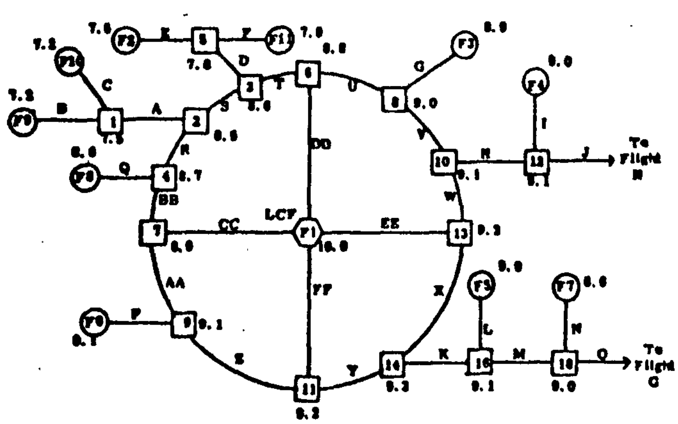


Figure 15F - Flight F



☐ Junction Number
○ LF Number
○ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF ONLY

Figure 15 - Pressure Distribution (pressure in psig)

Figure 15G - Flight G

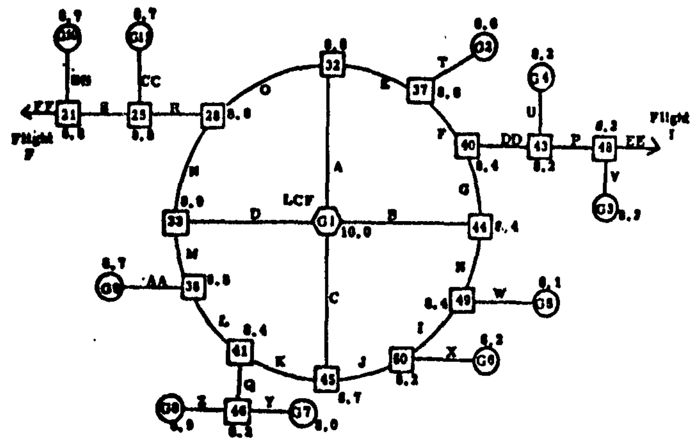
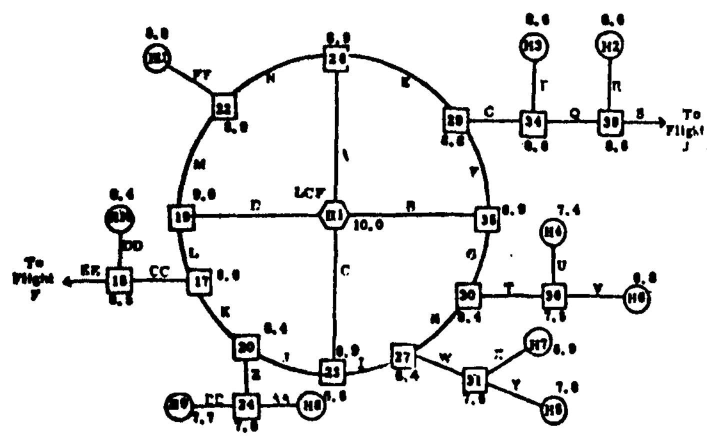


Figure 15H - Flight H



□ Junction Number
○ LF Number
○ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF ONLY

Figure 15 - Pressure Distribution (pressure in psig)

Figure 15I - Flight I

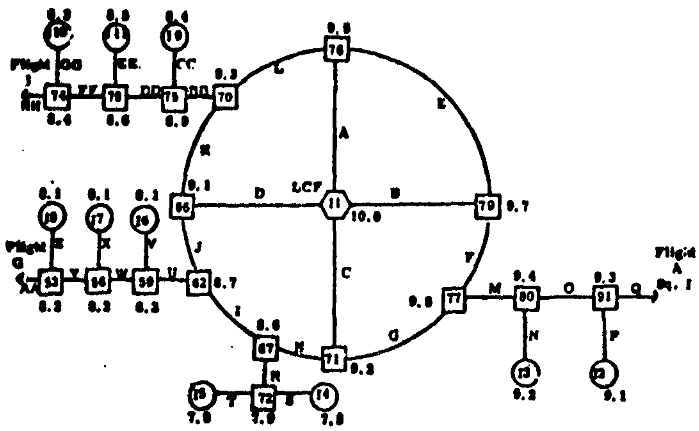
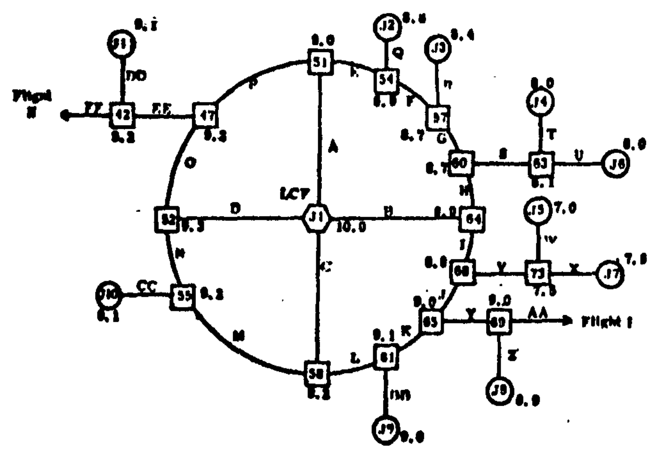


Figure 15J - Flight J



☐ Junction Number
○ LF Number
⬡ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF ONLY

Figure 15 - Pressure Distribution (pressure in psig)

Figure 15K - Flight K

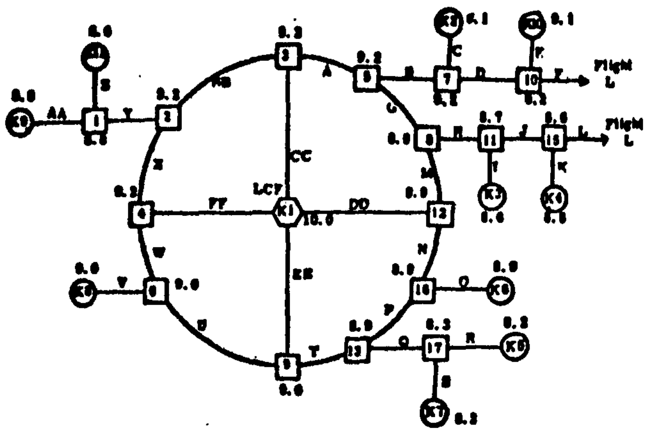
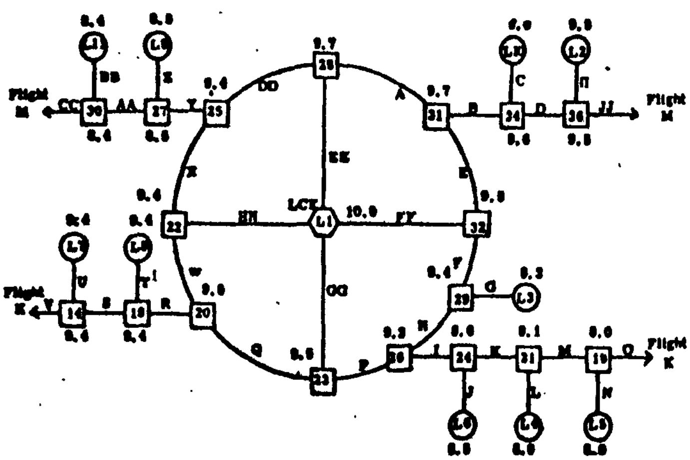


Figure 15L - Flight L



□ Junction Number
○ LF Number
○ LCF Number

Leakage Rate	<u>0.5 CFDM</u>
Pressurization Source	<u>LCF ONLY</u>

Figure 15 - Pressure Distribution (pressure in psig)

Figure 15M - Flight M

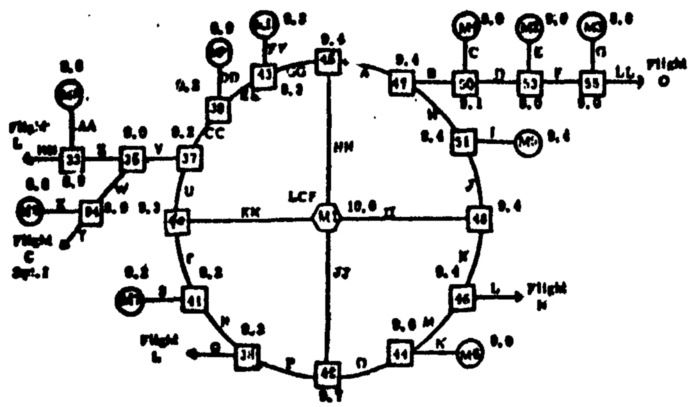
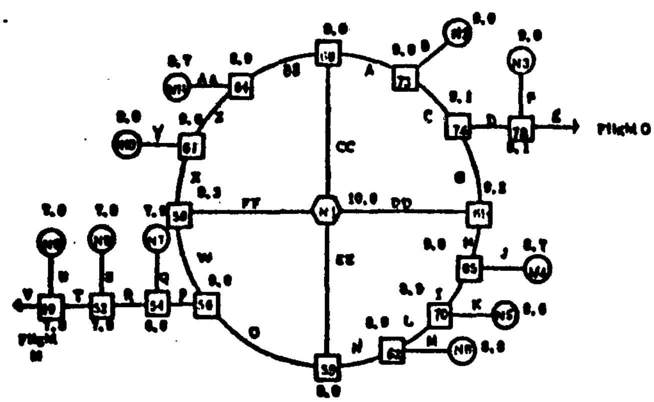


Figure 15N - Flight N



□ Junction Number
○ LF Number
○ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF ONLY

Figure 15 - Pressure in Distribution (pressure in psig)

Figure 15O - Flight O

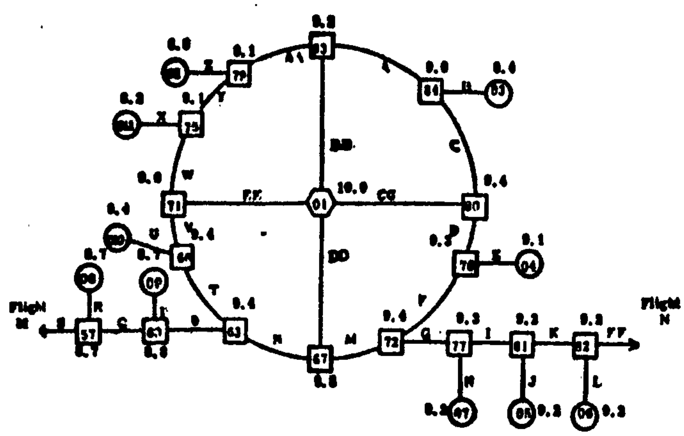


Figure 15 - Pressure Distribution (pressure in psig)

- ☐ Junction Number
- ○ LF Number
- ○ LCF Number

Leakage Rate	0.5 CFDM
Pressurization Source	LCF ONLY

Figure 16A - Flight A

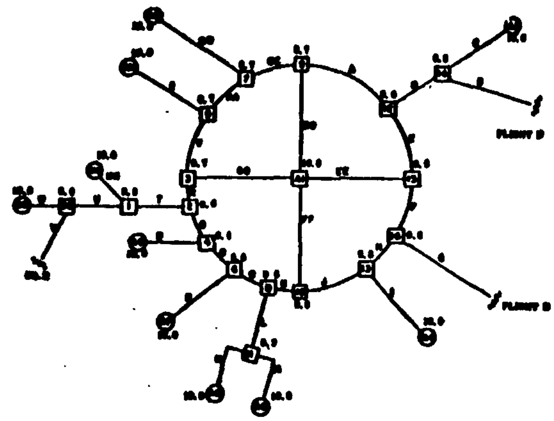
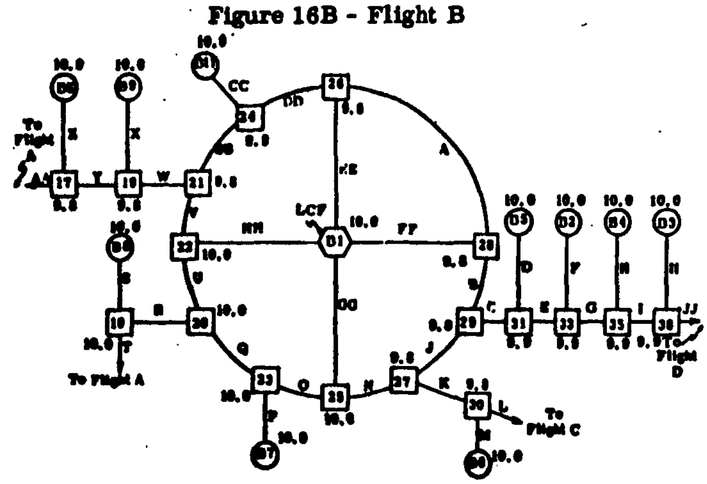


Figure 16B - Flight B



☐ **Junction Number**
○ **LF Number**
○ **LCF Number**

Leakage Rate <u>**0.5 CFDM**</u>
Pressurization Source <u>**LCF AND ALL LF'S**</u>

Figure 16 - Pressure Distribution (pressure in psig)

Figure 16C - Flight C

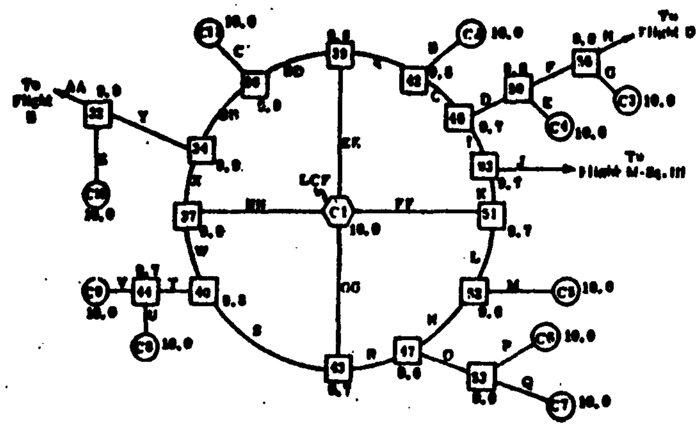
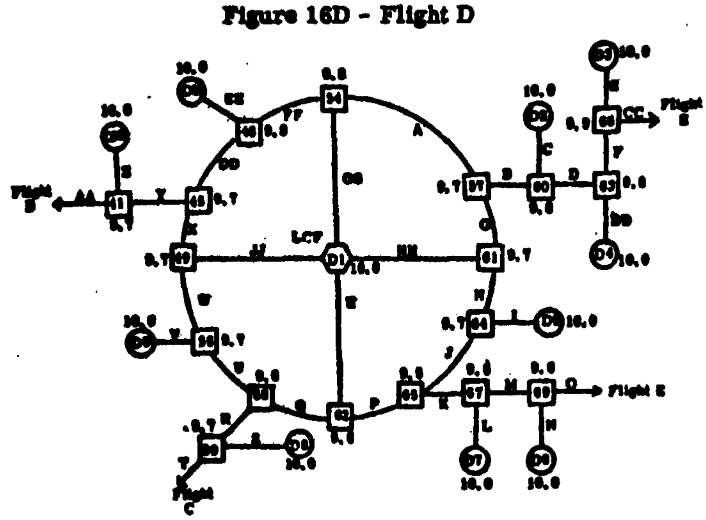


Figure 16D - Flight D



□ Junction Number
○ LF Number
○ LCF Number

Leakage Rate	0.5 CFDM
Pressurization Source	LCF AND ALL LF'S

Figure 16 - Pressure Distribution (pressure in psig)

Figure 16E - Flight E

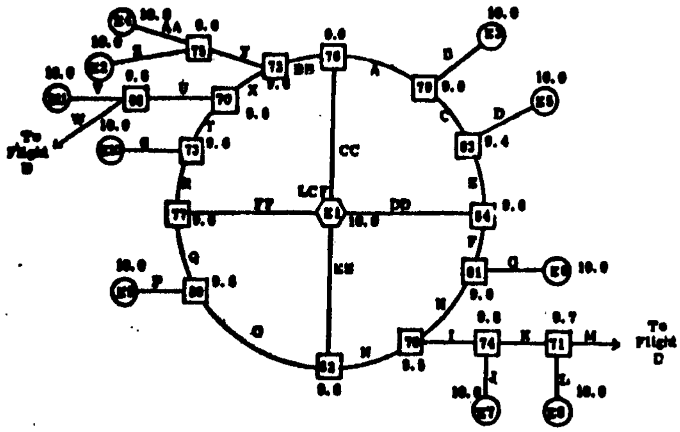
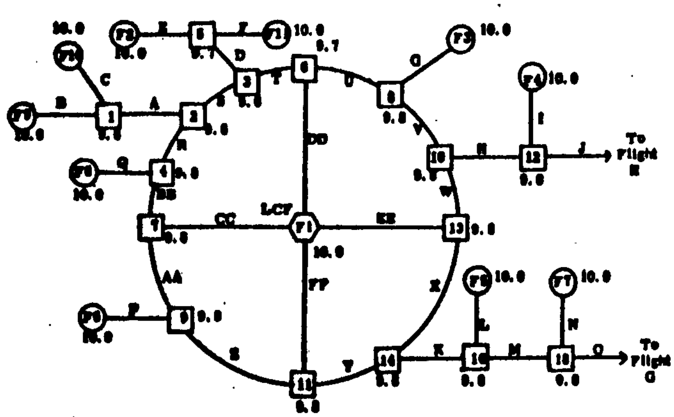


Figure 16F - Flight F



- ☐ Junction Number
- ○ LF Number
- ⬡ LCF Number

Leakage Rate: 0.5 CFDM
Pressurization Source: LCF AND ALL LF'S

Figure 16 - Pressure Distribution (pressure in psig)

Figure 16G - Flight G

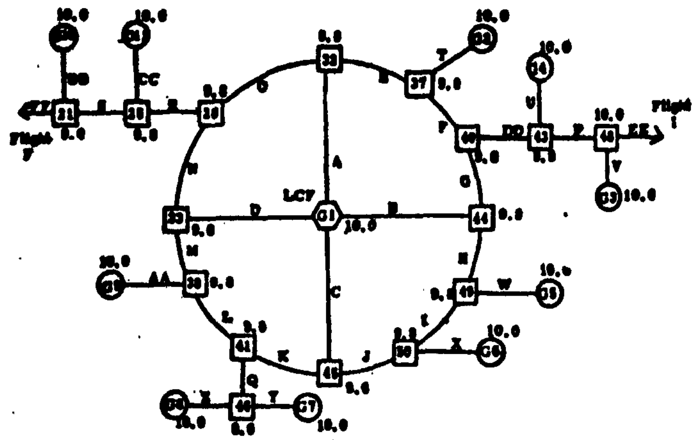
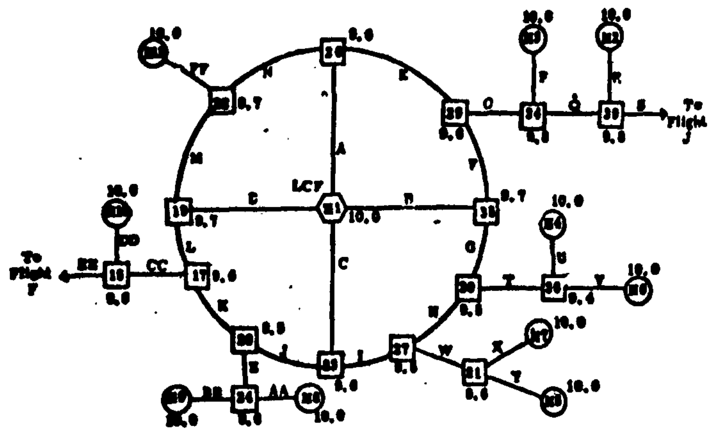


Figure 16H - Flight H



□ Junction Number
○ LF Number
○ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF AND ALL LF'S

Figure 16 - Pressure Distribution (pressure in psig)

Figure 16I - Flight I

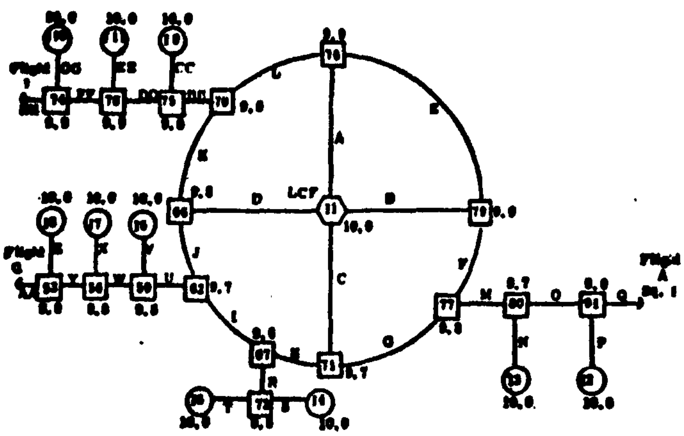
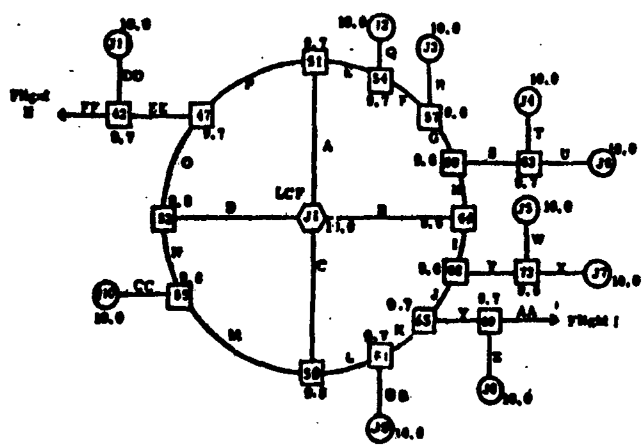


Figure 16J - Flight J



☐ Junction Number
O LF Number
O LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF AND ALL LF'S

Figure 16 - Pressure Distribution (pressure in psig)

Figure 16K - Flight K

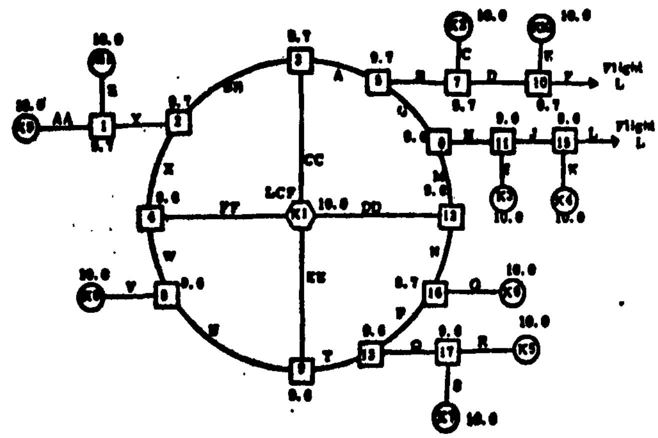
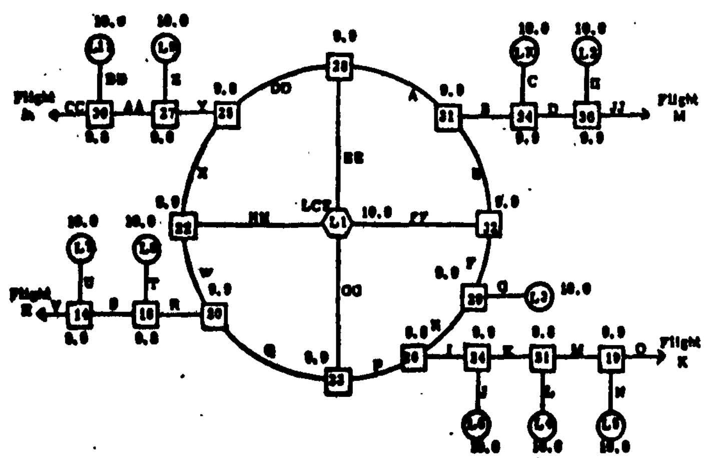


Figure 16L - Flight L



Junction Number
LF Number
LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF AND ALL LF'S

Figure 16 - Pressure Distribution (pressure in psig)

Figure 16M - Flight M

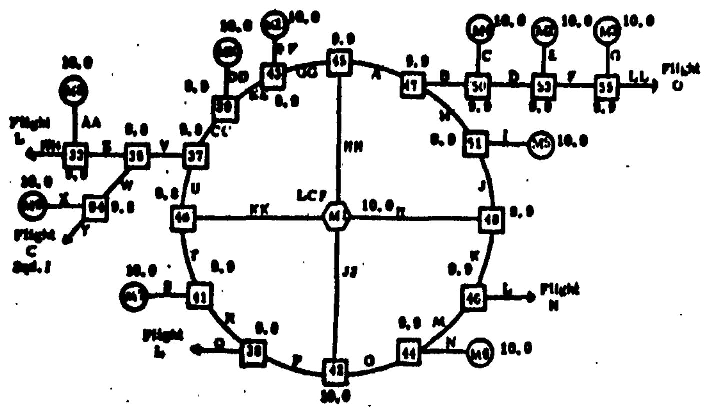
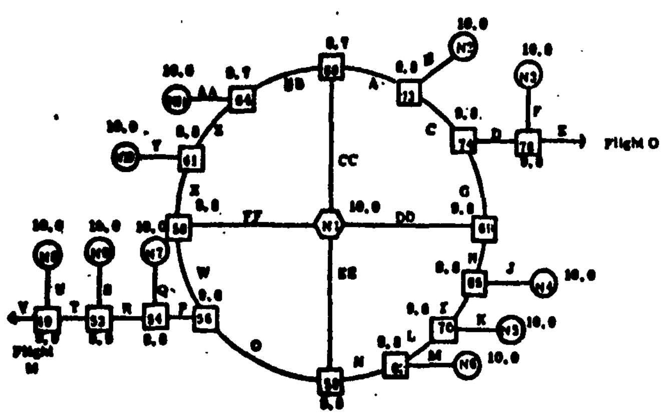


Figure 16N - Flight N



□ Junction Number
○ LF Number
○ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF AND ALL LF'S

Figure 16 - Pressure Distribution (pressure in psig)

Figure 16O - Flight O

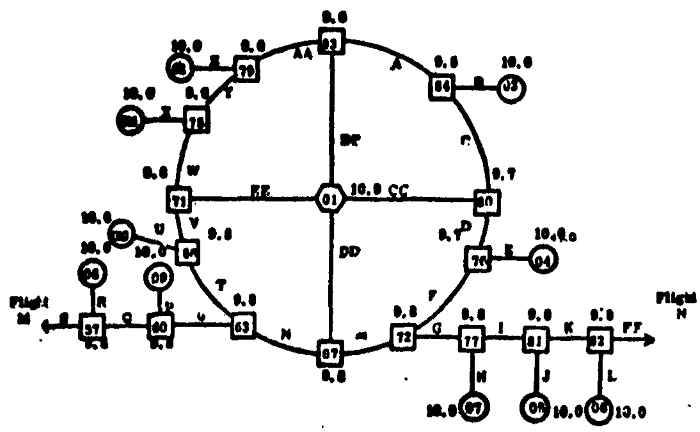


Figure 16 - Pressure Distribution (pressure in psig)

□ Junction Number
○ LF Number
○ LCF Number

Leakage Rate 0.5 CFDM
Pressurization Source LCF AND ALL LF'S

APPENDIX I

Calculation of R_p and R_L

A. Calculation of R_p.

In the Buried Cable Design Verification Program, measurements were made on various sizes of cable of the relation between airflow through a cable length to pressure drop over the cable length. It was found that the ratio $\frac{\text{Pressure Drop}}{\text{Air Flow}}$ varied only slightly with change in pressure drop (see MTOR-C-052, page III-9, figure 3. If a certain average pressure drop could be assumed, then the ratio $\frac{\text{Pressure Drop}}{\text{Air Flow}}$ could be considered a constant, and defined as the Pneumatic Resistance of the cable. Since the maximum network pressure is 10 psig, the compressor input pressure, and the minimum tolerable network pressure is 6 psig, the value at which a low-pressure alarm is sent, the maximum network pressure drop is 4 psi. Since this drop is distributed over several cables, it was felt that an average pressure drop of 1 psig could be assumed. The curves in MTOR-C-052, page III-9, figure 3 were extrapolated to form the curves shown in figure I-1 of this report. These curves show specific pneumatic resistance r_p in $\frac{\text{psi}}{\text{cfh}}$ per 1000 feet of cable length as a function of cable size. Cable size is expressed by the number of 16 AWG or 19 AWG wire pairs in the cable.

For a homogeneous cable (i.e. containing exclusively 16 AWG or exclusively 19 AWG wire pairs) the value of r_p taken from figure I-1 is multiplied by the length of the cable in thousands of feet to find R_p, the pneumatic resistance of the cable. A heterogeneous cable, containing both 16 AWG and 19 AWG wire pairs, is treated as having the same pneumatic resistance as two homogeneous cables in parallel. The specific pneumatic resistance of the heterogeneous cable is found by

$$r_p = \frac{\left(r_p \text{ 16 AWG}\right)\left(r_p \text{ 19 AWG}\right)}{\left(r_p \text{ 16 AWG}\right) + \left(r_p \text{ 19 AWG}\right)}$$

and this value of r_p is multiplied by the length of the cable in thousands of feet to find R_p, the pneumatic resistance.

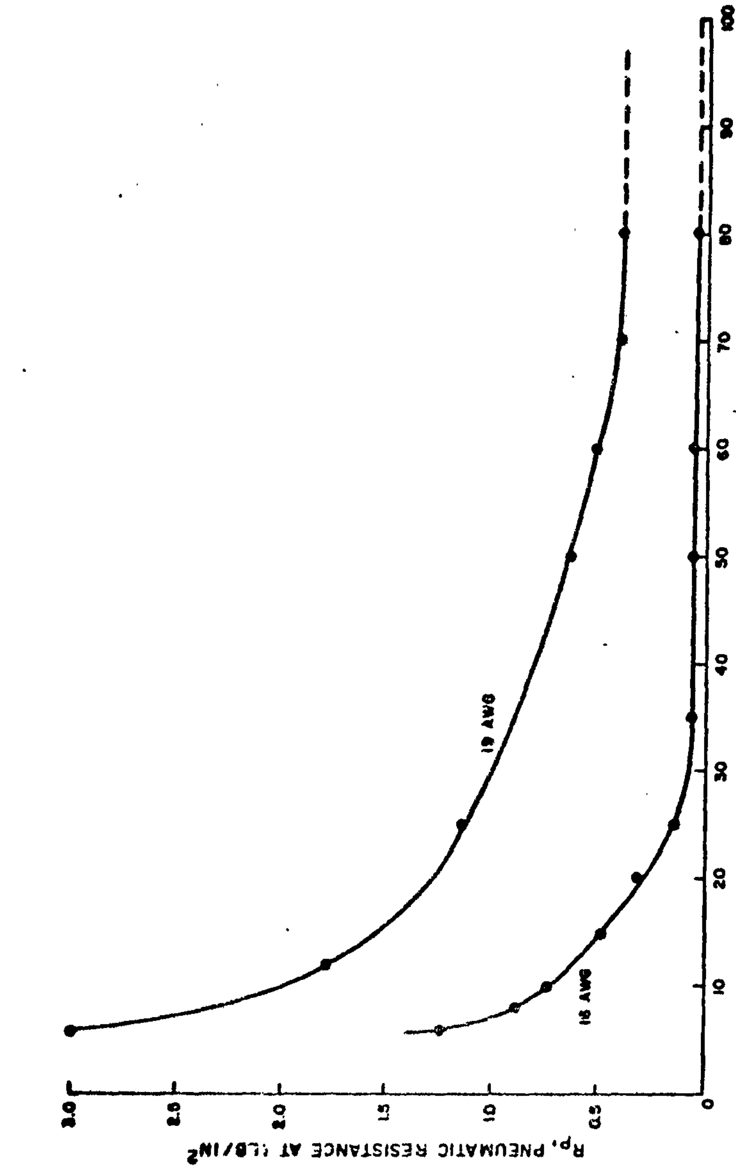


Figure I-1. Specific Pneumatic Resistance, r_p.

For example, cable HH, flight C contains 29 wire pairs of 16 AWG and 13 wire pairs of 19 AWG and is 16,100 feet long. Consulting the 16 AWG curve in figure I-1, r_p for 29 wire pairs is .08 $\frac{psi}{cfh}$ per 1000 feet. Consulting the 19 AWG curve in Figure I-1, r_p for 13 wire pairs is 1.70 $\frac{psi}{cfh}$ per 1000 ft. Therefore

$$r_p\text{, cable HH} = \frac{(.08)\ (1.70)}{(.08) + (1.70)} = .076\ \frac{psi}{cfh}\ \text{per 1000 ft.}$$

The length of the cable, in thousands of feet, is 16.1

$$R_p = .076 \times 16.1 = 1.23\ \frac{psi}{cfh}.$$

Where the number of pairs of one wire size in a cable is less than five pairs, the curves in figure I-1 are useless. In such a case, it was assumed that all wires in the cable were of the more populous size. For example, cable U, flight K, contains 6 pairs of 16 AWG and 2 pairs of 19 AWG. 16 AWG is the more populous size in this cable, so assume that all eight wire pairs in the cable are 16 AWG. Consulting the 16 AWG curve in figure I-1, r_p for eight pairs is 0.88 $\frac{psi}{cfh}$ per 1000 feet.

B. Calculation of R_L

This report considers leakage rates of 0.5 CFDM and 0.1 CFDM for a system pressurized to 10 psig. (CFDM is cubic feet per day per mile.) These two leakage rates, on an hourly basis, would be, respectively, $\frac{1}{48}$ and $\frac{1}{240}$ cfh per mile. Leakage conductance is the ratio of air flow to pressure. Based on an average 10 psi network pressure, the two leakage rates represent specific leakage conductances of $\frac{1}{480}\ \frac{cfh}{psi}$ per mile (0.5 CFDM) and $\frac{1}{2400}\ \frac{cfh}{psi}$ per mile (0.1 CFDM). These values, multiplied by the length of the cable in miles, gives the leakage conductance, G_L:

$$G_L = \frac{(\text{Miles})}{480}\ \frac{cfh}{psi} \qquad (0.5\ \text{CFDM})$$

$$G_L = \frac{(\text{Miles})}{2400}\ \frac{cfh}{psi} \qquad (0.1\ \text{CFDM})$$

Since leakage conductance is represented in simulation by an electrical resistor, it is convenient to speak of a leakage resistance, R_L, which is simply the reciprocal of the leakage conductance G_L:

$$R_L = \frac{1}{G_L}$$

$$R_L = \frac{480}{(\text{Miles})} \quad \frac{\text{psi}}{\text{cfh}} \quad (0.5 \text{ CFDM})$$

$$R_L = \frac{2400}{(\text{Miles})} \quad \frac{\text{psi}}{\text{cfh}} \quad (0.1 \text{ CFDM})$$

For example, cable HH flight C is 3.05 miles long. R_L for 0.5 CFDM is $\frac{480}{3.05} = 157.4 \frac{\text{psi}}{\text{cfh}}$. R_L for 0.1 CFDM is $\frac{2400}{3.05} = 787.0 \frac{\text{psi}}{\text{cfh}}$.

APPENDIX II

CABLE DATA

Tables IIA through II-0 show the size, length, and pneumatic properties of each cable in the Wing I buried cable network.

Column 1 in each table, "Designation", refers to the cable designations used in the pressure distribution maps, figs. 13 through 16 in the main body of this report.

Columns 2 and 3 in each table, "Number of Pairs," show the number of 16 AWG and 19 AWG pairs in each cable.

Column 4 shows the specific pneumatic resistance r_p for each cable, computed as described in Appendix I.

Columns 5 and 6 in each table give the length of the cable in miles and feet. For an interflight cable, half the total length of the cable is given.

Column 7 shows the pneumatic resistance R_p for each cable, computed as described in Appendix I.

Columns 8 and 9 show the leakage resistance R_L for each cable for leakage rates of 0.5 and 0.1 CFDM, computed as described in Appendix I.

TABLE II-A

CABLE DATA FOR - FLIGHT A, WING I

Cable Designation	No. of Pairs 16 AWG	No. of Pairs 19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_p	R_L 0.5 CFDM	R_L 0.1 CFDM
A	17	19	0.337	2.27	12,000	4.0	211.5	1057.5
B	14	14	0.400	1.50	7,940	3.2	320.0	1600.0
C	6	18	0.651	3.20	16,909	11.0	150.0	750.0
D	20	5.	0.290	19.70	104,016	30.2	24.4	122.0
E	9	8	0.596	1.70	9,000	5.4	282.4	1412.0
F	36	6	0.068	1.14	6,030	0.4	421.1	2105.5
G	44	2	0.07	14.6	77,088	5.4	32.9	164.5
H	18	5	0.36	0.949	5,012	1.8	505.8	2529.0
I	12	12	0.465	5.25	27,725	12.9	91.4	457.0
J	12	8	0.496	2.27	12,001	6.0	211.5	1057.5
K	17	15	0.318	1.33	7,000	2.2	360.9	1804.5
L	14	7	0.439	12.599	66,525	29.2	38.1	190.5
M	9	6	0.628	5.99	31,603	19.9	80.1	400.5
N	5	10	2.0	6.93	36,600	73.2	69.3	346.5
O	9	11	0.560	2.24	11,839	6.6	214.3	1071.5
P	9	12	0.552	6.23	32,915	18.2	77.1	385.5
Q	0	14	1.630	1.62	8,557	14.0	296.3	1481.5
R	3	12	1.780	8.82	46,590	82.9	54.4	272.0
S	3	5	2.33	2.588	13,664	31.8	185.5	927.5
T.	27	17	0.111	5.92	31,275	3.5	81.1	405.5
U	27	11	0.113	5.28	27,900	3.2	90.9	454.5
V	24	2	0.170	8.9	46,992	8.0	53.9	269.5
W	3	12	1.78	3.56	18,815	33.5	134.8	674.0
X	24	12	0.150	1.89	10,000	1.5	254.0	1270.0
Y	0	14	1.63	1.136	6,000	9.8	422.5	2112.5
Z	6	15	0.689	8.25	43,571	30.0	58.2	291.0
AA	6	8	0.809	1.136	6,000	4.9	422.5	2112.5
BB	6	15	0.689	4.35	22,977	15.8	110.4	552.0
CC	12	14	0.454	1.7	9,000	4.1	282.4	1412.0
DD	5	16	1.49	2.72	14,375	21.4	176.5	882.5
EE	29	5	0.06	3.62	19,128	1.5	132.6	663.0
FF	5	22	1.21	3.10	16,362	19.6	154.8	774.0
GG	24	22	0.149	3.54	18,669	2.8	135.6	678.0
HH	0	15	1.55	3.01	15,885	24.6	159.5	797.5

TABLE II-B

CABLE DATA FOR - FLIGHT B, WING I

Cable Designation	No. of Pairs 16 AWG	19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_p	R_L 0.5 CFDM	0.1 CFDM
A	0	5	3.400	5.09	26,904	91.47	94.2	471.5
B	9	28	0.454	1.02	5,389	2.45	470.1	2350.6
C	18	33	0.260	5.14	27,118	7.05	93.5	467.3
D	9	15	0.528	2.77	14,651	7.74	173.0	864.9
E	21	27	0.203	1.04	5,515	1.12	459.3	2296.6
F	9	15	0.528	2.60	13,747	7.26	184.3	921.6
G	24	21	0.150	4.72	24,950	3.74	101.6	507.9
H	14	14	0.400	3.42	18,076	7.23	140.2	701.1
I	26	16	0.120	3.97	20,956	2.51	120.9	604.7
J	12	8	0.496	2.43	12,822	6.36	197.7	988.5
K	47	14	0.058	3.60	19,013	1.10	133.3	666.5
L	86	2	0.060	3.91	20,671	1.24	122.6	613.0
M	9	15	0.528	3.16	16,712	8.82	151.6	758.3
N	4	15	1.550	1.74	9,196	14.25	275.5	1377.7
O	9	14	0.537	0.36	1,922	1.03	1318.7	6593.4
P	9	15	0.528	3.06	16,171	8.54	156.7	783.5
Q	6	8	0.809	1.39	7,340	5.94	345.3	1726.6
R	35	14	0.067	4.33	22,857	1.53	110.9	554.4
S	44	2	0.060	3.84	20,275	1.22	125.0	625.0
T	9	15	0.528	3.68	19,427	10.26	130.5	652.4
U	35	15	0.067	0.88	4,668	0.31	543.0	2714.9
V	9	8	0.596	2.82	14,885	8.87	170.3	851.4
W	9	22	0.482	4.02	21,221	10.23	119.4	579.2
X	9	15	0.528	3.04	16,038	8.47	158.0	790.0
Y	12	16	0.443	4.05	21,368	9.47	118.6	593.0
Z	8	20	0.521	3.32	17,532	9.13	144.6	722.9
AA	20	5	0.290	2.00	10,560	3.06	240.0	1200.0
BB	12	17	0.437	1.16	6,138	2.68	412.7	2063.6
CC	9	15	0.528	5.20	27,471	14.50	92.2	461.3
DD	3	23	1.100	1.08	5,724	6.30	442.8	2214.0
EE	3	19	1.250	3.16	16,669	20.84	152.0	760.2
FF	6	24	0.597	3.12	16,450	9.82	154.0	770.2
GG	32	16	0.056	3.24	17,134	0.96	147.9	739.6
HH	26	14	0.120	3.17	16,749	2.01	151.3	756.6
II	15	9	0.392	3.05	16,104	6.31	157.4	786.9
JJ	29	10	0.077	3.23	17,054	1.313	148.6	743.0

TABLE II-C

CABLE DATA FOR - FLIGHT C, WING I

Cable Designation	No. of Pairs 16 AWG	No. of Pairs 19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_P	R_L 0.6 CFDM	R_L 0.1 CFDM
A	6	15	0.689	1.31	6,917	4.8	366.4	1832.0
B	6	15	0.689	2.86	15,101	10.4	167.8	839.0
C	6	9	0.785	1.24	6,548	5.1	387.1	1935.5
D	11	23	0.428	6.42	36,898	14.5	74.8	374.0
E	9	18	0.505	2.60	13,728	6.9	184.6	923.0
F	20	14	0.246	1.27	6,600	1.6	377.9	1889.5
G	9	15	0.528	4.10	21,648	11.4	117.1	585.6
H	29	2	0.060	6.48	34,241	2.7	74.0	370.0
I	5	13	1.37	1.05	5,544	7.6	457.1	2285.5
J	0	28	1.05	8.47	44,748	47.0	56.6	283.0
K	5	40	0.80	1.05	5,544	4.4	457.1	2285.5
L	3	15	1.37	2.15	11,352	15.5	223.2	1116.0
M	3	14	1.43	5.29	27,931	39.9	90.7	453.5
N	0	9	2.14	1.9	10,032	21.5	252.6	1263.0
O	9	18	0.505	4.28	22,598	11.4	112.1	560.5
P	3	15	1.37	3.3	17,424	27.0	145.4	727.0
Q	6	12	0.731	7.8	41,184	30.1	61.5	307.5
R	9	12	0.552	0.84	4,435	2.4	571.4	2857.0
S	9	11	0.560	1.75	9,240	5.1	274.3	1371.5
T	9	15	0.528	4.21	22,229	11.7	114.0	570.0
U	6	12	0.731	4.53	23,918	17.5	106.0	530.0
V	3	12	1.78	7.14	37,699	67.1	67.2	336.0
W	12	5	0.630	1.83	9,662	6.1	262.3	1311.5
X	41	9	0.068	2.80	14,784	1.0	171.4	857.0
Y	50	11	0.058	2.40	12,672	0.73	200.0	1000.0
Z	12	12	0.465	3.23	17,054	7.9	148.6	743.0
AA	66	2	0.060	3.91	20,671	1.2	122.6	613.0
BB	9	11	0.560	1.70	8,976	5.0	282.3	1411.5
CC	9	15	0.528	2.64	13,939	7.4	181.8	909.0
DD	6	11	0.746	2.20	11,616	8.7	218.2	1091.0
EE	0	17	1.43	3.26	17,213	24.6	147.2	736.0
FF	2	50	0.65	3.11	16,421	10.7	154.3	771.5
GG	0	20	1.28	3.02	15,946	20.4	158.9	794.5
HH	29	13	0.076	3.05	16,104	1.2	157.4	787.0

TABLE II-D

CABLE DATA FOR - FLIGHT D, WING I

Cable Designation	No. of Pairs 16 AWG	No. of Pairs 19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_P	R_L 0.5 CFDM	R_L 0.1 CFDM
A	16	28	0.329	1.54	8,128	2.7	311.7	1558.4
B	31	27	0.203	7.93	41,882	8.5	60.5	302.6
C	9	15	0.528	2.74	14,453	7.6	175.2	875.9
D	24	21	0.150	5.33	28,165	4.2	90.1	450.3
E	18	10	0.305	2.36	12,470	3.8	203.4	1016.9
F	25	23	0.125	0.20	1,062	0.1	2400.0	12000.0
G	12	2	0.530	2.60	13,740	7.3	184.6	923.1
H	11	12	0.487	1.93	10,186	5.0	248.7	1243.5
I	12	12	0.487	4.01	21,157	10.3	119.7	598.5
J	5	9	1.63	3.41	18,002	29.3	140.8	703.8
K	11	20	0.440	5.39	28,474	12.5	89.0	445.3
L	8	18	0.651	4.50	23,878	15.5	106.7	533.3
M	5	17	1.20	3.76	19,833	23.8	127.7	638.3
N	6	18	0.651	4.70	24,809	16.1	102.1	510.6
O	5	8	1.70	2.60	13,708	23.3	184.9	923.1
P	12	14	0.454	1.84	9,707	4.4	260.9	1304.3
Q	17	11	0.330	2.24	11,825	3.9	214.3	1071.4
R	26	14	0.120	2.40	12,646	1.5	200.0	1000.0
S	9	15	0.528	2.70	14,373	7.6	177.8	888.9
T	29	2	0.080	6.485	34,241	2.7	74.0	370.1
U	16	6	0.412	1.15	6,067	2.5	417.4	2087.0
V	9	15	0.528	3.92	20,704	10.9	122.4	612.2
W	18	12	0.300	1.02	5,408	1.6	470.6	2352.9
X	20	20	0.236	1.03	5,428	1.3	466.0	2330.1
Y	26	22	0.117	3.70	19,517	2.3	129.7	648.6
Z	9	15	0.528	3.86	20,362	10.7	124.3	621.8
AA	29	10	0.077	3.23	17,054	1.3	148.6	743.0
BB	11	13	0.481	3.64	19,222	9.2	131.9	659.3
CC	29	18	0.076	4.81	25,402	1.9	99.8	498.9
DD	12	11	0.471	2.64	13,925	6.6	181.8	909.1
EE	9	15	0.528	4.24	22,386	11.8	113.2	566.0
FF	9	11	0.560	1.57	8,279	4.6	305.7	1528.7
GG	8	28	0.485	3.1	16,362	7.9	154.8	774.7
HH	5	11	1.48	3.23	17,039	25.2	148.6	743.0
II	5	18	1.18	3.57	18,855	22.2	134.4	672.3
JJ	2	23	1.18	3.53	18,662	22.0	136.0	679.9

TABLE II-E

CABLE DATA FOR - FLIGHT E, WING I

Cable Designation	No. of Pairs 16 AWG	No. of Pairs 19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_p	R_L 0.5 CFDM	R_L 0.1 CFDM
A	6	11	0.731	0.82	4341	3.2	583.9	2919.7
B	3	16	1.37	3.19	16864	23.1	150.3	751.4
C	3	8	2.33	2.47	13045	30.3	194.2	971.3
D	3	15	1.37	6.85	36173	49.6	70.1	350.3
E	9	11	1.78	2.01	10625	18.9	238.6	1192.8
F	9	11	1.78	1.19	6300	11.2	402.7	2013.4
G	3	15	1.37	2.95	15560	21.3	162.9	814.4
H	3	11	1.63	1.41	7435	12.1	340.9	1704.5
I	5	17	1.20	2.96	15653	18.8	162.2	810.8
J	3	15	1.37	3.19	16850	23.1	150.6	752.3
K	6	11	0.598	9.11	48076	28.7	52.7	263.4
L	7	18	0.588	2.47	13028	7.7	194.3	971.7
M	6	8	1.70	2.60	13708	23.3	184.9	923.1
N	8	15	0.569	1.11	5876	3.3	431.3	2156.3
O	6	2	0.88	4.23	22334	19.6	113.5	567.4
P	6	13	0.717	3.33	17561	12.6	144.3	721.6
Q	6	12	0.731	1.44	7536	5.5	334.0	1670.1
R	9	11	0.598	2.33	12287	7.3	206.3	1031.4
S	3	18	1.24	2.24	11818	14.6	214.5	1072.4
T	12	14	0.454	1.11	5889	2.7	430.5	2152.3
U	23	28	0.168	3.04	16080	2.7	157.6	788.2
V	6	15	0.689	3.82	20180	13.9	125.6	627.9
W	29	16	0.076	4.81	25402	1.9	99.8	498.9
X	17	23	0.299	1.48	7831	2.3	323.7	1618.3
Y	9	18	0.543	7.87	41574	22.6	61.0	304.8
Z	3	15	1.37	4.37	23088	31.6	109.8	547.6
AA	6	12	0.731	4.60	24300	17.8	104.3	521.5
BB	8	32	0.465	1.08	5680	2.6	446.1	2230.5
CC	2	34	0.88	3.34	17630	15.5	143.8	718.8
DD	0	15	1.55	3.36	17735	27.5	142.9	714.5
EE	2	14	1.47	3.25	17169	25.2	147.6	738.0
FF	3	15	1.37	3.24	17084	23.4	148.3	741.7

TABLE II-F

CABLE DATA FOR - FLIGHT F, WING I

Cable Designation	No. of Pairs 16 AWG	No. of Pairs 19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_p	R_L 0.6 CFDM	R_L 0.1 CFDM
A	9	12	0.552	8.18	43187	23.8	58.7	293.4
B	6	16	1.850	3.65	19262	29.9	131.6	657.9
C	9	6	0.627	6.06	32008	20.1	79.2	396.9
D	9	18	0.543	7.06	37267	20.2	68.0	340.0
E	3	15	1.370	4.93	26018	36.6	97.4	487.0
F	6	12	0.731	3.63	19173	14.0	132.2	661.0
G	9	16	0.528	3.30	17434	9.2	145.4	726.8
H	20	11	0.077	2.93	15484	1.2	163.6	818.3
I	12	12	0.465	4.27	22563	10.5	112.3	561.7
J	30	3	0.080	5.22	27577	2.2	91.9	459.5
K	48	9	0.058	4.84	25580	1.5	99.1	495.4
L	9	12	0.552	3.26	17238	9.5	147.0	736.1
M	61	6	0.059	1.66	8779	0.5	288.6	1443.2
N	7	7	0.734	8.29	43800	32.1	57.9	289.3
O	62	3	0.060	3.08	16241	1.0	157.0	780.2
P	12	12	0.465	3.14	16558	7.7	153.1	765.3
Q	9	15	0.528	3.07	16217	8.6	156.3	781.5
R	6	6	0.809	1.55	8196	6.6	309.3	1546.4
S	9	11	0.560	1.06	5606	3.1	452.0	2259.9
T	12	20	0.422	1.02	5401	2.3	469.2	2346.0
U	18	6	0.396	3.26	17218	6.8	147.2	736.2
V	18	5	0.200	2.34	12380	2.5	204.7	1023.4
W	24	7	0.160	0.98	5190	0.8	488.3	2441.5
X	15	2	0.400	3.82	20185	8.1	125.6	627.8
Y	33	6	0.059	1.19	6310	0.4	401.7	2008.4
Z	18	6	0.312	1.93	10210	3.2	248.2	1241.0
AA	6	5	0.670	3.13	16519	11.1	153.4	767.0
BB	9	14	0.536	1.60	8443	4.5	300.2	1500.9
CC	3	12	1.550	3.18	16772	26.0	151.1	755.4
DD	3	24	1.060	3.26	17226	18.6	147.1	735.5
EE	18	8	0.398	3.24	17111	6.8	148.1	740.5
FF	15	15	0.367	3.13	16544	6.1	153.2	766.0

TABLE II - G

CABLE DATA FOR - FLIGHT G, WING I

Cable Designation	No. of Pairs 16 AWG	No. of Pairs 19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_p	R_L 0.5 CFDM	R_L 0.1 CFDM
A	3	12	1.55	2.93	15476	24.0	163.8	819.1
B	1	33	0.94	3.64	19224	18.1	131.9	659.3
C	0	8	1.37	3.64	19229	26.3	131.9	659.3
D	13	20	0.39	3.88	20487	8.1	123.7	618.6
E	9	11	0.56	1.55	8160	4.6	309.7	1548.4
F	6	5	0.67	2.42	12770	8.6	198.3	991.7
G	22	36	0.18	1.06	5590	1.0	452.8	2264.1
H	21	8	0.226	1.83	9680	2.2	262.3	1311.5
I	9	5	0.53	3.25	17180	9.1	147.7	738.4
J	0	11	1.87	3.92	20970	39.2	120.9	604.5
K	9	14	1.63	1.58	8350	13.6	303.8	1519.0
L	6	8	0.809	1.84	9695	7.8	260.8	1304.3
M	15	14	0.371	0.76	4000	1.5	631.6	3157.9
N	28	13	0.094	1.60	8450	0.8	300.0	1500.0
O	9	8	0.809	3.60	18990	15.4	133.3	666.7
P	34	27	0.067	1.07	5670	0.3	448.6	2243.0
Q	6	21	0.621	2.09	11050	6.8	229.7	1148.3
R	34	20	0.057	4.01	21195	1.2	119.7	598.5
S	43	14	0.058	2.67	14115	0.8	179.8	898.9
T	9	19	0.500	2.59	13665	6.8	185.3	926.6
U	14	14	0.400	3.17	16732	6.7	151.4	757.1
V	6	18	0.651	3.49	18450	12.0	137.5	687.7
W	12	12	0.465	6.91	36457	16.9	69.5	347.3
X	9	15	0.528	3.09	16320	8.6	155.3	776.7
Y	6	15	0.689	4.25	22442	15.5	112.9	564.7
Z	0	15	1.550	10.09	53296	82.7	47.6	237.9
AA	9	15	0.528	3.46	18355	9.7	137.9	689.7
BB	9	15	0.528	2.62	13840	7.3	183.2	916.0
CC	9	15	0.528	3.65	19256	10.2	131.5	657.5
DD	28	30	0.091	9.8	51744	4.7	49.0	244.9
EE	36	22	0.057	3.78	19958	1.1	127.0	634.9
FF	52	2	0.060	3.08	16241	1.0	157.0	780.2

TABLE II-H

CABLE DATA FOR - FLIGHT H, WING I

Cable Designation	No. of Pairs 16 AWG	19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_p	R_L 0.5 CFDM	0.1 CFDM
A	9	9	2.14	3.56	18796	40.2	134.8	674.2
B	15	20	0.349	3.89	20544	7.2	123.4	615.0
C	7	17	0.599	2.67	14073	8.4	179.8	898.9
D	12	14	0.484	3.84	18686	8.5	135.6	678.0
E	3	8	1.88	3.16	16674	31.3	151.9	759.5
F	21	10	0.222	1.46	7725	1.7	328.8	1643.8
G	12	11	0.471	2.49	12890	6.1	192.8	963.9
H	9	5	0.530	1.07	5643	3.0	448.6	2243.0
I	8	9	0.624	1.90	10039	6.3	252.6	1263.2
J	8	11	1.48	1.24	6562	9.7	387.1	1935.5
K	6	5	0.670	3.65	19275	12.9	131.5	657.5
L	18	15	0.292	3.25	17157	5.0	147.7	738.5
M	6	8	0.809	2.06	10899	8.8	232.0	1166.0
N	3	8	1.880	1.87	9860	18.5	256.7	1283.4
O	24	17	0.152	5.20	27478	4.2	92.3	461.5
P	12	12	0.465	3.30	17409	8.1	145.4	727.3
Q	30	14	0.076	0.90	4767	0.4	533.3	2666.7
R	9	16	0.528	2.66	14067	7.4	180.4	902.3
S	30	2	0.060	3.10	16368	1.0	154.8	774.2
T	15	9	0.392	7.10	37494	14.7	67.6	338.0
U	6	12	0.731	5.20	27471	20.1	92.3	461.5
V	9	6	0.827	12.20	64400	40.4	39.3	196.7
W	11	13	0.481	5.16	27217	13.1	93.0	465.1
X	6	10	1.56	8.96	47323	73.3	53.6	267.9
Y	6	12	0.731	3.52	18560	13.6	136.4	681.8
Z	11	13	0.480	4.83	25478	12.2	90.4	496.9
AA	5	10	1.660	10.71	56564	87.7	44.8	224.1
BB	6	12	0.731	3.70	19543	14.3	129.7	648.6
CC	24	11	0.156	4.50	23753	3.7	106.7	533.3
DD	12	12	0.465	2.43	12817	6.0	197.5	987.6
EE	30	2	0.060	5.22	27577	-2.2	91.9	459.5
FF	9	15	0.528	3.12	16477	8.7	153.8	769.2

TABLE II - I

CABLE DATA FOR - FLIGHT I, WING I

Cable Designation	No. of Pairs 16 AWG	No. of Pairs 19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_p	R_L 0.5 CFDM	R_L 0.1 CFDM
A	22	10	0.182	3.28	17298	3.1	146.3	731.7
B	27	6	0.115	3.52	18609	2.1	136.4	681.8
C	8	19	1.33	3.13	16504	21.9	153.3	766.8
D	6	36	0.811	3.53	18633	9.5	136.0	679.9
E	3	2	1.50	5.39	28467	42.7	89.0	445.3
F	30	5	0.076	3.39	17910	1.4	141.6	708.0
G	6	12	0.731	2.44	12905	9.4	196.7	983.6
H	6	8	0.809	2.54	13402	10.8	189.0	944.9
I	12	14	0.456	1.82	9626	4.4	263.7	1318.7
J	8	35	0.450	1.56	8223	3.7	307.7	1538.5
K	9	2	0.660	2.96	15609	10.3	162.2	810.8
L	26	9	0.122	1.50	7941	1.0	320.0	1600.0
M	30	14	0.076	2.82	14913	1.1	170.2	851.1
N	3	12	1.55	4.02	21233	32.9	119.4	597.0
O	27	11	0.112	3.36	17727	2.0	142.8	714.3
P	3	12	1.55	3.56	18812	29.2	134.8	674.2
Q	24	2	0.130	8.52	44986	5.8	56.3	281.7
R	18	19	0.292	9.67	51039	14.9	49.6	248.2
S	9	12	0.552	5.55	29293	16.2	86.5	432.4
T	9	12	0.552	3.19	16823	9.3	150.5	752.3
U	21	34	0.197	5.82	30741	6.1	82.5	412.4
V	6	18	0.651	3.94	20776	13.5	121.8	609.1
W	27	31	0.106	1.02	5402	0.6	470.6	2352.9
X	9	15	0.528	3.61	19056	10.1	133.0	664.8
Y	30	31	0.065	1.91	10104	0.7	251.3	1256.5
Z	12	12	0.465	4.15	21935	10.2	115.7	578.3
AA	36	22	0.057	3.78	19958	1.1	127.0	634.9
BB	29	10	0.077	7.05	37223	2.9	68.1	340.4
CC	8	7	0.711	8.07	42631	30.3	59.5	297.4
DD	27	6	0.115	6.35	33551	3.8	75.6	377.9
EE	24	6	0.161	3.18	16799	2.7	150.9	754.7
FF	27	9	0.114	6.78	35798	4.1	70.8	354.0
GG	18	6	0.321	3.76	19853	6.3	127.7	638.3
HH	27	6	0.115	4.36	23021	2.6	110.1	550.5

TABLE II - J

CABLE DATA FOR - FLIGHT J, WING I

Cable Designation	No. of Pairs 16 AWG	No. of Pairs 19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_P	R_L 0.5 CFDM	R_L 0.1 CFDM
A	0	15	1.65	3.17	16715	25.9	151.4	757.1
B	9	15	0.528	3.19	16842	8.9	150.5	752.3
C	12	20	0.421	2.89	15254	6.4	166.1	830.4
D	12	14	0.456	3.18	16778	7.6	150.9	754.7
E	12	17	0.437	1.03	5432	2.4	466.0	2330.1
F	5	11	1.47	1.25	6606	9.7	384.0	1920.0
G	15	11	0.382	1.36	7199	2.7	353.0	1765.7
H	12	14	0.456	1.51	7970	3.6	317.9	1589.4
I	21	2	0.200	0.98	5196	1.0	489.8	2449.0
J	18	2	0.400	2.53	13341	5.3	189.7	948.6
K	21	6	0.231	0.99	5238	1.2	484.8	2424.2
L	21	22	0.206	0.98	5150	1.1	489.8	2449.0
M	9	11	0.560	2.37	12506	7.0	202.5	1012.7
N	9	11	0.560	2.05	10830	6.1	234.1	1170.7
O	21	10	0.222	1.23	6500	1.4	390.0	1951.2
P	12	5	0.400	3.40	17956	7.2	141.2	705.9
Q	3	15	1.370	3.58	18902	25.9	134.1	670.4
R	6	15	0.689	6.62	34964	24.1	72.5	362.5
S	15	18	0.356	8.15	43052	15.3	58.9	294.5
T	6	15	0.689	3.87	20434	14.1	124.0	620.1
U	9	12	0.552	3.49	18417	10.2	137.5	687.7
V	18	3	0.250	14.71	77664	19.4	32.6	163.1
W	9	6	0.627	10.24	54060	33.9	46.9	234.4
X	9	6	0.627	3.72	19647	12.3	129.0	645.2
Y	30	15	0.076	2.36	12484	0.9	203.4	1016.9
Z	9	12	0.552	3.81	20114	11.1	126.0	630.0
AA	27	6	0.115	4.36	23021	2.6	110.1	550.5
BB	6	15	0.689	4.03	21291	14.7	119.1	595.5
CC	6	15	0.689	3.16	16656	11.5	151.9	759.5
DD	6	15	0.689	3.34	17627	12.1	143.7	718.6
EE	33	14	0.058	2.13	11239	6.6	225.3	1126.7
FF	39	2	0.060	3.10	16366	1.0	154.8	774.2

TABLE II-K

CABLE DATA FOR - FLIGHT K, WING I

Cable Designation	No. of Pairs 16 AWG	No. of Pairs 19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_p	R_L 0.5 CFDM	R_L 0.1 CFDM
A	37	14	0.067	1.53	8096	0.5	313.7	1568.6
B	46	17	0.058	0.98	5200	0.3	484.8	2424.2
C	6	15	0.689	3.18	16769	11.5	150.9	754.7
D	46	11	0.058	1.93	10200	0.6	248.7	1243.5
E	9	12	0.552	3.50	18476	10.2	137.1	685.7
F	42	2	0.060	3.13	16526	1.0	153.3	766.8
G	18	12	0.378	4.09	21599	8.2	117.4	586.8
H	36	20	0.118	6.41	33842	4.0	74.9	374.4
I	6	16	0.689	3.15	16617	11.4	152.4	761.9
J	36	14	0.120	4.32	22801	2.7	111.11	555.6
K	6	15	0.689	2.89	15246	10.5	166.1	830.4
L	36	2	0.100	3.27	17260	1.7	146.8	734.2
M	11	17	0.456	1.15	6061	2.7	417.4	2087.0
N	12	8	0.496	0.95	5013	2.5	505.3	2526.3
O	9	12	0.552	3.43	18109	10.0	139.9	699.7
P	9	5	0.600	1.63	8596	6.9	294.5	1472.4
Q	18	3	0.250	12.2	64352	16.1	39.4	196.9
R	9	6	0.627	3.06	16167	10.1	156.9	784.3
S	9	6	0.627	3.50	18486	11.6	137.1	685.7
T	18	9	0.300	2.07	10904	3.3	231.9	1159.4
U	6	2	0.680	2.29	12077	10.6	209.6	1048.0
V	9	12	0.552	3.13	16507	9.1	153.3	766.8
W	3	11	1.63	3.19	16817	27.4	150.5	752.3
X	3	8	1.88	1.85	9752	18.3	259.5	1297.0
Y	18	18	0.356	4.82	25432	9.0	99.6	497.9
Z	9	12	0.552	7.66	40442	22.3	62.7	313.3
AA	6	15	0.689	2.46	12998	8.9	195.1	975.6
BB	18	11	0.302	1.12	5890	1.6	428.6	2142.9
CC	19	24	0.257	3.34	17645	4.6	143.7	718.6
DD	5	18	1.17	3.09	16334	19.1	155.3	776.7
EE	9	6	0.627	3.15	16618	10.4	152.4	761.9
FF	0	12	1.78	3.09	16307	29.0	155.3	776.7

TABLE II - L

CABLE DATA FOR - FLIGHT L, WING I

Cable Designation	No. of Pairs 16 AWG	19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_p	R_L 0.5 CFDM	0.1 CFDM
A	31	6	0.068	2.10	11094	0.7	228.6	1142.9
B	40	8	0.059	4.31	22750	1.3	111.4	556.8
C	12	12	0.465	2.56	13531	6.3	187.5	937.5
D	40	8	0.060	5.77	30466	1.8	83.2	415.9
E	9	8	0.530	3.07	16199	8.6	156.3	781.6
F	16	18	0.367	1.32	6972	2.6	363.6	1818.2
G	12	12	0.465	3.15	16643	7.7	152.4	761.9
H	9	14	0.537	1.16	6140	3.3	413.8	2064.0
I	8	22	0.482	3.84	20295	9.8	125.0	625.0
J	9	15	0.528	2.79	14723	7.8	172.0	860.2
K	12	16	0.443	4.35	22961	10.2	110.3	551.7
L	11	17	0.456	3.32	17516	8.0	144.6	722.9
M	23	8	0.184	4.57	24109	4.4	105.0	525.2
N	15	9	0.392	3.26	17213	6.7	147.2	736.2
O	26	2	0.100	3.27	17260	1.7	146.8	734.2
P	6	11	0.746	2.23	11780	8.8	215.2	1076.2
Q	25	15	0.128	2.29	12071	1.5	209.6	1048.0
R	34	17	0.058	1.40	7400	0.4	342.8	1714.3
S	34	14	0.056	2.89	15261	0.9	166.1	830.4
T	12	12	0.465	4.15	21914	10.2	115.7	578.3
U	9	15	0.528	3.40	17971	9.5	141.2	705.9
V	43	2	0.060	3.13	16537	1.0	153.3	766.3
W	9	5	0.530	3.26	17201	9.1	147.2	736.2
X	14	2	0.440	2.15	11346	5.0	223.3	1116.3
Y	17	8	0.341	9.34	49326	16.8	51.4	257.0
Z	12	12	0.465	2.93	15467	7.2	163.8	819.1
AA	23	5	0.100	2.66	14019	1.4	180.4	902.3
BB	18	6	0.321	4.31	22733	7.3	111.4	556.8
CC	23	2	0.140	3.28	17302	2.4	146.5	732.4
DD	9	9	0.582	1.58	8356	4.9	303.8	1519.0
EE	28	12	0.095	3.14	16590	1.6	152.9	764.3
FF	6	19	0.642	3.12	16445	10.6	153.8	769.2
GG	19	17	0.268	3.05	16120	4.3	157.4	786.9
HH	5	0	1.870	3.44	18182	34.0	139.5	697.7
II	18	6	0.321	3.65	19272	6.2	131.5	657.5
JJ	40	2	0.060	2.76	14573	0.9	173.9	869.6

TABLE II-M

CABLE DATA FOR - FLIGHT M, WING I

Cable Designation	No. of Pairs 16 AWG	No. of Pairs 19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_p	R_L 0.5 CFDM	R_L 0.1 CFDM
A	40	2	0.060	2.58	13698	0.8	186.0	930.2
B	37	5	0.060	11.25	59383	3.6	42.7	213.3
C	18	9	0.392	2.88	15192	6.0	166.7	833.3
D	34	5	0.060	2.17	11430	0.7	221.2	1106.0
E	22	6	0.213	3.19	16859	3.6	150.5	752.4
F	38	8	0.067	6.21	32777	2.8	72.3	386.5
G	12	12	0.468	3.78	19963	9.3	127.0	634.9
H	27	4	0.070	1.06	5616	0.4	452.8	2264.1
I	9	15	0.528	3.07	16221	8.6	156.3	781.8
J	30	12	0.076	1.80	9494	0.7	266.7	1333.3
K	37	22	0.109	1.10	5787	0.6	436.4	2181.8
L	3	18	1.360	4.23	22334	30.4	113.5	567.4
M	9	11	0.560	3.80	20054	11.2	126.3	631.6
N	9	16	0.528	3.23	17077	9.0	148.6	743.0
O	12	11	0.471	1.00	5286	2.5	480.0	2400.0
P	3	7	2.000	1.22	6421	12.8	393.4	1967.2
Q	40	2	0.060	2.76	14573	0.9	173.9	869.6
R	21	8	0.226	2.97	15685	3.5	161.6	806.1
S	9	15	0.528	2.79	14719	7.8	172.0	860.2
T	18	8	0.312	1.14	5883	1.8	421.0	2105.3
U	18	50	0.232	0.89	4679	1.1	539.3	2696.6
V	27	40	0.101	5.67	29942	3.0	84.6	423.3
W	9	40	0.400	1.25	6594	2.6	384.0	1920.0
X	9	15	0.528	2.81	14809	7.8	170.8	854.1
Y	0	28	1.050	8.48	44744	47.0	56.6	283.0
Z	24	16	0.152	4.84	25554	3.9	99.2	495.9
AA	11	17	0.456	3.40	17937	8.2	141.2	705.9
BB	23	2	0.140	3.28	17302	2.4	146.5	732.4
CC	21	44	0.187	1.22	6422	1.2	393.4	1967.2
DD	9	15	0.528	8.81	46539	24.6	54.5	272.4
EE	18	8	0.321	0.91	4776	1.5	527.5	2637.4
FF	12	12	0.468	3.14	16597	7.7	152.9	764.3
GG	18	11	0.302	1.19	6301	1.9	403.4	2016.8
HH	22	12	0.203	3.44	18154	3.7	139.5	697.7
II	9	19	0.500	3.71	19606	9.8	129.4	646.9
JJ	19	11	0.280	3.02	15925	4.5	158.9	794.7
KK	0	61	0.630	3.19	16843	10.6	150.5	752.4
LL	28	5	0.060	4.96	26136	1.6	97.0	484.8

TABLE II-N

CABLE DATA FOR - FLIGHT N, WING I

Cable Designation	No. of Pairs 16 AWG	No. of Pairs 19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_p	R_L 0.5 CFDM	R_L 0.1 CFDM
A	6	8	0.509	3.81	20099	16.3	126.0	629.9
B	8	15	0.528	3.89	20567	10.8	123.4	617.0
C	15	14	0.371	1.80	9493	3.5	266.7	1333.3
D	40	14	0.058	5.17	27278	1.6	92.8	464.2
E	47	2	0.060	3.06	16164	1.0	157.4	786.9
F	9	15	0.528	4.62	24415	12.9	103.9	519.5
G	26	16	0.126	1.64	8648	1.1	292.7	1463.4
H	12	11	0.471	2.81	14849	7.0	170.8	854.1
I	9	11	0.560	1.00	5300	3.0	480.0	2400.0
J	3	15	1.360	4.53	23916	32.5	106.0	529.8
K	3	15	1.360	5.55	29303	39.9	86.5	432.4
L	6	17	0.663	1.59	8379	5.6	301.9	1509.4
M	9	12	0.552	4.02	21234	11.7	119.4	597.0
N	3	14	1.430	0.95	5022	7.2	505.3	2526.3
O	6	5	0.070	1.45	7673	0.5	331.0	1655.2
P	20	19	0.245	10.77	56846	13.9	44.6	223.8
Q	12	12	0.466	4.83	25516	11.9	99.4	496.9
R	26	16	0.120	5.40	28508	3.4	88.9	444.4
S	20	6	0.266	2.71	14310	3.8	177.1	885.6
T	24	21	0.160	1.87	9874	1.6	256.7	1283.4
U	15	9	0.392	2.62	13836	5.4	183.2	916.0
V	3	15	1.36	4.23	22334	30.4	113.5	567.4
W	14	15	0.395	1.80	9510	3.8	266.7	1333.3
X	3	8	1.88	1.45	7642	14.4	331.0	1655.2
Y	6	12	0.731	3.03	15979	11.7	158.4	792.1
Z	3	5	2.33	2.80	14798	34.5	171.4	857.1
AA	6	12	0.731	5.90	31158	22.8	81.4	406.8
BB	6	11	0.731	1.19	6303	4.6	403.4	2016.8
CC	8	12	1.790	3.51	18535	33.0	136.8	683.8
DD	13	19	0.399	3.40	17968	7.2	141.2	705.9
EE	3	18	1.24	3.47	18309	22.7	136.3	681.6
FF	11	22	0.430	2.99	15806	6.8	160.5	802.7

TABLE II - O

CABLE DATA FOR - FLIGHT O, WING I

Cable Designation	No. of Pairs 16 AWG	No. of Pairs 19 AWG	r_p Per 1000 Ft.	Cable Length (Miles)	Cable Length (Feet)	R_p	R_L 0.5 CFDM	R_L 0.1 CFDM
A	0	11	1.88	1.76	9283	17.6	272.7	1363.6
B	0	15	1.55	7.61	40161	62.4	63.1	315.4
C	0	5	3.00	1.96	10331	31.0	244.9	1224.5
D	3	11	1.63	1.01	5333	8.7	452.2	2376.2
E	3	15	1.30	3.18	16814	22.9	150.9	754.7
F	6	5	0.67	4.90	25884	17.3	98.0	489.8
G	28	20	0.064	2.21	11640	1.0	217.2	1086.0
H	12	12	0.466	3.51	18513	8.6	136.7	683.8
I	34	17	0.058	1.30	6860	0.4	369.2	1846.1
J	9	15	0.528	3.76	19827	10.5	127.7	638.3
K	43	11	0.058	6.71	35409	2.0	71.5	357.7
L	12	12	0.466	3.95	20856	9.7	121.5	607.6
M	22	16	0.197	1.32	6947	1.4	363.6	1818.2
N	9	9	0.530	2.28	12031	6.4	210.5	1052.6
O	21	13	0.219	8.80	46435	10.2	54.5	272.7
P	9	15	0.528	3.60	19024	10.0	133.3	666.7
Q	30	6	0.078	5.41	28577	2.2	88.7	443.6
R	18	10	0.306	2.99	15786	4.8	160.5	802.7
S	28	5	0.060	4.95	26136	1.6	97.0	484.8
T	24	10	0.157	1.03	5423	0.8	466.0	2330.1
U	6	15	0.689	3.93	20723	14.3	122.1	610.7
V	18	16	0.280	0.98	5169	1.5	489.8	2449.0
W	3	11	1.63	1.35	7106	11.6	355.6	1777.8
X	0	15	1.55	9.41	49704	77.0	51.0	255.0
Y	3	11	1.63	1.76	9280	15.1	272.7	1363.6
Z	3	15	1.30	4.52	23861	32.4	106.2	531.0
AA	0	11	1.88	1.51	7960	15.0	317.9	1589.0
BB	0	15	1.55	3.26	17199	26.6	147.2	736.2
CC	3	19	1.41	3.45	18237	25.7	139.1	695.6
DD	12	23	0.380	3.30	17414	6.8	145.4	727.3
EE	18	18	0.356	2.99	15761	5.6	160.5	802.7
FF	47	2	0.060	3.06	16104	1.0	157.4	786.9

APPENDIX III

Interconnection Junction Error - Individual Flight Simulation

As previously explained, the flight simulator panels can be operated in either of two ways:

a. All flights interconnected. There are electrical connections between the flight simulator panels, representing the interflight cables.

b. Individual flight simulation. There are no connections between flight simulator panels. Instead, the interflight cables are represented on each panel by half-tees: resistive tees equivalent to one half the length of the total interflight cable.

The readings taken with the two methods are different; the all-flights-interconnected method is the more accurate simulation. Table III-1 shows the pressure at interconnection junctions (junctions at each end of an interflight cable) measured under these two methods of simulation. "Error" is the difference between readings taken by the two methods, with the all-flights-interconnected method considered correct. Readings were taken for pressurization at LCFs only and pressurization at LCFs and all LFs; all at 0.5 CFDM leakage rate.

TABLE III-1

Comparison of Individual Flight Simulation with Interconnected - Flight Simulation
(This table shows pressure at interconnection junctions using interconnected - flight simulation and individual flight simulation. Pressure in psig. All values at 0.5 CFDM leakage rate.)

Interconnection Junction	LCF's only Pressurized			LCF's and all LF's Pressurized		
	Interconnected Flight Simulation	Individual Flight Simulation	Difference	Interconnected Flight Simulation	Individual Flight Simulation	Difference
A14	6.5	6.6	0.1	8.6	8.2	0.4
A16	8.6	8.5	0.1	9.0	9.3	0.3
A92	6.6	6.0	0.6	7.6	7.5	0.1
B17	5.6	5.2	0.4	8.6	9.2	0.6
B18	8.7	9.0	0.3	9.7	9.8	0.1
B30	7.2	6.7	0.5	8.9	8.9	0
B38	4.4	4.0	0.4	9.0	9.2	0.2
C32	8.5	8.8	0.3	9.4	9.4	0
C56	4.2	3.8	0.4	8.7	8.8	0.1
C93	-	6.8		-	8.6	
D41	4.6	5.0	0.4	8.8	8.6	0.2
D59	4.4	4.7	0.3	8.6	8.5	0.1
D66	4.1	3.7	0.4	9.1	9.3	0.2
D59	2.2	2.2	0	8.6	8.5	0.1
E68	4.7	4.5	0.2	8.7	8.2	0.5
E71	2.0	2.1	0.1	8.7	8.8	0.1
F12	6.5	6.7	0.2	8.7	8.7	0
F18	6.4	6.6	0.2	8.8	8.7	0

TABLE III-1 (Continued)

Interconnection Junction	LCF's only Pressurized			LCF's and all LF's Pressurized		
	Interconnected Flight Simulation	Individual Flight Simulation	Difference	Interconnected Flight Simulation	Individual Flight Simulation	Difference
G21	6.3	6.0	0.3	8.9	9.0	0.1
G48	4.3	4.2	0.1	9.5	9.6	0.1
H15	6.2	5.6	0.6	8.7	8.7	0
H39	6.6	5.8	0.8	8.9	9.0	0.1
I53	4.4	4.5	0.1	9.2	8.7	0.5
I74	5.9	5.1	0.8	8.9	9.0	0.1
I91	-	7.3		-	8.2	
J42	6.7	7.2	0.5	8.8	8.7	0.1
J69	6.3	6.7	0.4	8.6	8.6	0
K10	7.1	6.9	0.2	9.0	9.0	0
K15	4.5	4.9	0.4	8.8	8.7	0.1
L14	7.2	7.4	0.2	9.0	9.0	0
L19	4.3	3.5	0.8	8.9	9.1	0.2
L30	5.0	4.5	0.5	8.9	9.0	0.1
L36	7.5	7.8	0.3	9.1	9.2	0.1
M33	5.2	5.3	0.1	8.8	8.7	0.1
M38	7.4	7.0	0.4	9.0	8.8	0.2
M46	7.3	7.5	0.2	9.0	9.0	0
M55	5.1	5.5	0.4	8.9	8.9	0
M94	-	5.5		-	8.6	
N49	3.9	3.3	0.6	9.3	9.3	0
N78	6.1	6.2	0.1	8.6	8.6	0
O57	4.9	4.1	0.8	9.0	9.0	0
O62	6.1	6.0	0.1	8.7	8.8	0.1