direct current system, operating at 28 volts. Four generators, one mounted on each engine, supplied the electrical power for the system. Power for operation of a.c. electrical instruments and equipment was provided by two inverters with outputs of 115 v. at 400 cps. Where necessary the 115-v. inverter output was reduced by stepdown transformers to 26 v. for operation of certain instruments.

Since the electrical system, as such, was destroyed in the ground fire, its integrity before impact must be established through an evaluation of crew and passenger statements, evidence obtained in the examination of system components, and results of tests performed during the accident investigation.

The four generators were recovered, disassembled, and examined. Although impact and fire had damaged them, there was no indication that they had failed electrically or had been in any manner incapable of normal operation prior to the accident.

## Cabin Lights Dim

Passengers reported that the cabin lights became dim and for some time were off altogether when the aircraft was at the hangar for snow removal operations. These reports do not indicate electrical system difficulty. The dimming of the lights indicates a gradual drop in bus voltage after the engines were stopped and the batteries became the only source of electrical power. The period during which the lights were off altogether represents the time during which the battery master switch was turned off to prevent discharge of the batteries.

Normal electrical system behavior was reported after leaving the hangar. All lighting, instrument, and radio operation were reported as being normal. The flight engineer noted that the output of all generators was normal during the engine runup.

It was reported that the cabin lights, "seat belt," and "no smoking" signs, cockpit lights, and landing lights all functioned normally throughout the takeoff and short flight.

There can be little doubt that the basic d.c. electrical system of the aircraft was functioning normally.

## Crew's Testimony

The crew testified that the inverters had been turned on in the normal manner, i.e., captain's inverter switch, "up" position; first officer's inverter switch, "down" position; engine instrument inverter switch, "down" position.

In this configuration, Phase A of the upper inverter supplies power to the following receivers: No. 1 VHF Navigation, No. 1 VHF Communications, and No. 1 ADF. Phase C supplies power to operate the captain's course indicator and the indicator system of No. 1 ADF. Both phases are used in supplying power to the C-2A Gyrosyn compass.

There exists ample evidence that both phases were intact and supplying power before takeoff and during the flight. Phase A power is confirmed by the normal reception of tower communications on No. 1 VHF receiver up to and including the instruction received after becoming airborne to change to departure control frequency. No difficulties were reported in the operation of



No. 1 VHF navigation receiver and No. 1 ADF. Phase C is confirmed by normal indications of No. 1 ADF observed prior to takeoff. The indication of a 272-deg. heading on the azimuth ring of the course indicator, after the accident, confirms operation of this instrument during the flight. Since the course indicator repeats C-2A Gyrosyn compass heading, that unit must have operated normally. The C-2A Gyrosyn compass uses both Phase A and Phase C power.

The captain's turn-and-bank indicator and gyro horizon indicator were powered by both Phase A and Phase C of the upper inverter. The 115-v. output was dropped to 26v. for operation of these instruments by means of an instrument transformer. Fuses were installed in the primary and secondary circuits of the transformer. A relay controlling power to the captain's inverter failure warning light was connected across Phase A and Phase C of the secondary side, at a point between the secondary fuses and the instruments. In this fashion the relay would sense the Phase A to Phase B voltage and act to turn on the warning light when voltage dropped below a pre-set amount.

It is apparent that the Phase C power was available beyond the transformer, and to the relay, since the warning light did not come on as it did in the tests on N 34953 whenever the Phase C primary or secondary fuses were removed.

Absence of a warning light indicates that this fuse was also intact.

## Voltage Loss

One other condition remains to be explored; loss of Phase A primary voltage due to melting of the Phase A primary fuse. It was demonstrated in the tests on N 34953 that removal of this fuse did not result in immediate inverter failure warning light indication. Secondary voltage decayed over a period of approximately five minutes before the light came on. The voltage at that time was approximately 23 v. The gyro horizon had not tumbled at that time but continued to function for approximately two more minutes. The drop-out voltage specified for the relay is 18.5 v. It is apparent that the relay installed in N 34953 was set at a higher value. Had it operated at 18.5 v., the light would have remained off for a longer period and it is possible that the gyro horizon might have tumbled before the light came on.

One area that cannot be explored is the possible failure of an electrical connection or wire at or within one of these instruments. Such a condition would result in an inoperative instrument without the appearance of a warning light.

Power to operate the engine instruments and the wing flap position indicator is taken from Phase A of the lower inverter, at a point ahead of the Phase A, 115-v. circuit breaker. The voltage is then stepped down to the 26 v. required by these instruments by means of an auto-transformer. All engine instrument indications were reported as being normal in flight and the operation of the wing flap position indicator was observed as the flaps were retracting. This indicates that the Phase A output of the lower inverter was normal and that its circuit was intact from the inverter to the point