SECTION VI—FLIGHT CHARACTERISTICS

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FLIGHT CHARACTERISTICS.

This aircraft exhibits no flight characteristics that would tend to place the pilot in a difficult situation. It has been flown under a wide variety of weather conditions including thunderstorms, gusty crosswind landings, and severe icing. General performance and flight characteristics under such conditions have been described as good by service operating personnel. Its handling qualities are normal in every respect. Control response under typical flight conditions and with asymmetrical power is considered excellent.

NOTE

The information contained in this section is based on experience gained from flight and service tests accomplished on previous civilian and military models of Constellation aircraft.

STALL CHARACTERISTICS.

The stall characteristics of this aircraft, with any combination of wing flap or landing gear positions, are excellent and the stall is preceded by adequate warning in the form of mild buffeting. There is no abnormal tendency for a wing to drop and aileron and rudder control is effective up to and into the actual stall through both power-on and power-off stalls. With a forward center of gravity, the control forces necessary to slow the aircraft to the stall speed will be fairly heavy and will increase as the speed is reduced. At the stall, a pronounced nose-down pitch will occur; however, if the center of gravity is moved near the aft limit, the forces necessary to accomplish the stall will be greatly reduced and this nose-down pitching tendency at the stall will also be reduced. With increased power, the stall occurs at a more pronounced nose-up attitude, at a lower speed, with a slight increase in rolling tendency and a reduction in stall warning. The stall speeds for angles of bank are given in figure 6-1. Values shown are reliable for the flight conditions noted. However, indicated airspeed may vary from equivalent airspeed values shown at the actual stall. Readings will depend on individual IAS instrument calibrations, system in use, rate of speed reduction, power setting, and other factors which affect the indication or the stall speed. Therefore this chart should be used primarily as a basis for establishing minimum desired flight speed margins above stall speed to be observed in normal operations.

ACCELERATED STALLS.

Accelerated stalls are similar to level flight unaccelerated stalls, except that the warning margin, normally 3 to 5 knots above the stall, is somewhat reduced. During progressive stalls (one stall immediately following another), no change occurs in the stall characteristics with each succeeding stall. However, if only a partial recovery is effected between stalls, a considerable increase in rolling tendency and buffeting will result.

NOTE

Flight in the stall area where severe airframe buffet occurs may possibly cause some fuel system leaks. Therefore, practice stalls performed for the purpose of indoctrination demonstrations should not be carried into the stall area, but be limited to approach-to-stall speeds. This will provide adequate demonstration of buffet characteristics, and reduce possibility of damage to the airframe or component equipment. The technique for recovering from stalls of any nature is to move the control column forward and apply whatever aileron and rudder control and power is necessary to keep the wings level.

EC-121G STALL SPEED CURVE

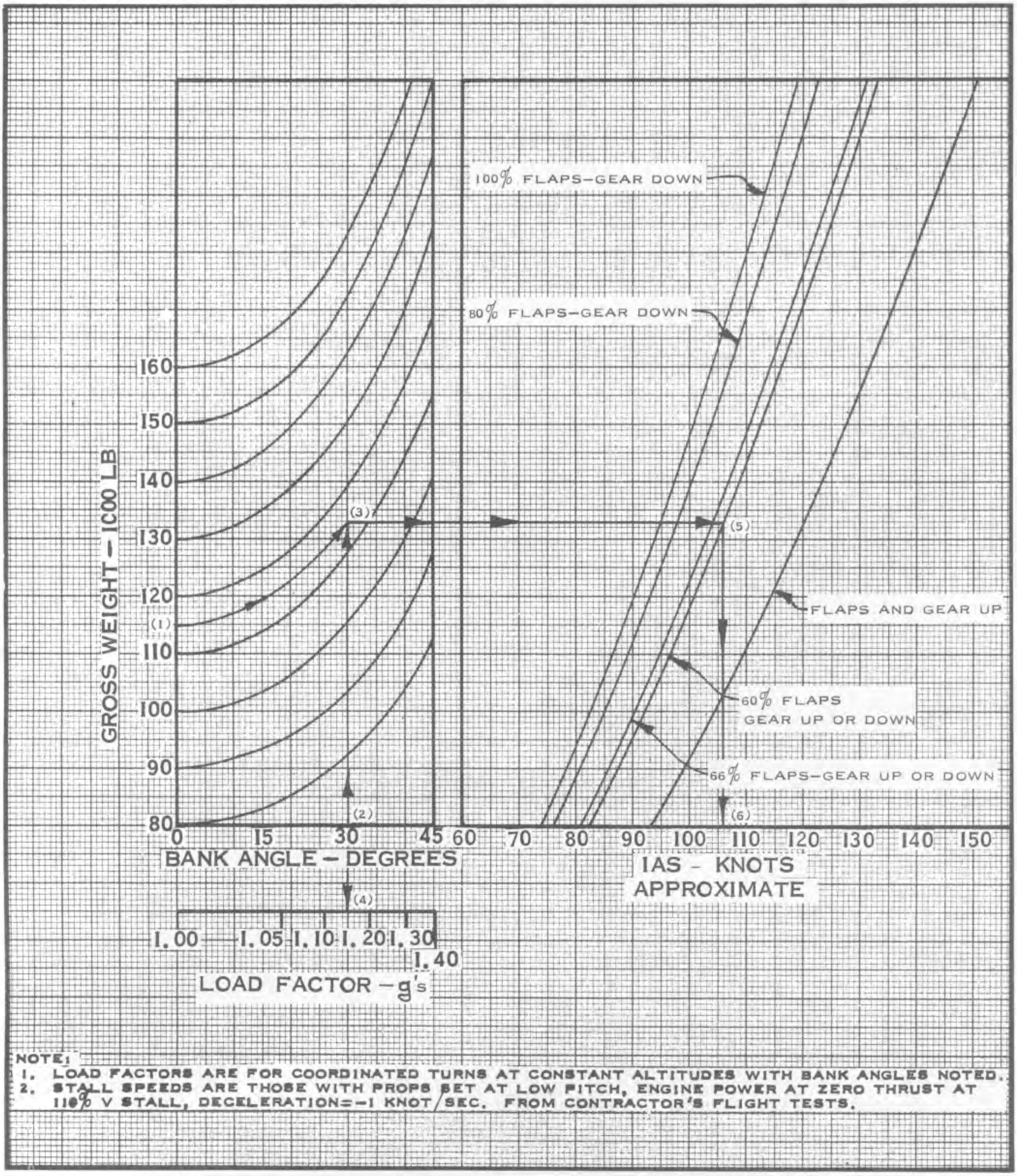

Figure 6-1

WARNING

A critical flight condition is a combination of high power, low speed, and a nose-up attitude. When applying power, make certain that airspeed increases as power is applied, and maintain a minimum attitude change because of undue control forces and controllability.

SPIN CHARACTERISTICS.

WARNING

Intentional spins with this aircraft are prohibited.

No spin tests have been conducted with Constellation-type aircraft; however, in the event of an inadvertent spin, it is believed that a normal spin recovery method, consisting of the application of opposite rudder followed by the forward movement of the wheel, would accomplish recovery. Furthermore, it is recommended that the control column not be pushed forward of its neutral position, as excessive buildup in airspeed might result. Avoid excessive back pressure on the wheel during the pullout after recovery.

FLIGHT CONTROLS.

In order to perform their primary mission efficiently, aircraft in the patrol and transport categories are designed to withstand lower load factors than some other types, such as attack bombers and fighters which require greater maneuverability. To reduce the possibility of inadvertently applying structural loads greater than those for which they are designed, transport have a very high degree of stability. Because of this stability, the control forces necessary to perform maneuvers are somewhat greater than those required on other aircraft types.

Trim Devices.

All control systems are equipped with conventional mechanically operated trim tabs.

NORMAL OPERATION.

The aileron, elevator, and rudder control systems are conventional in every way except that they are partially powered by means of hydraulic booster units. Since these booster units do not completely accomplish the movement of the surfaces but merely assist in this movement, "feel" of the controls is retained by the pilot. To maintain this feeling and to prevent overcontrolling, the booster units are designed to provide low boost ratios for small control force applications, and to increase boost ratios as the applied control force is increased.

BOOST-OUT OPERATION.

The possibility of the booster units becoming inoperative is rather remote since the boosters are operable with either the primary or secondary hydraulic system inoperative. If both of these systems fail, the auxiliary booster systems will still provide hydraulic pressure to the rudder and elevator booster units. If a situation arises which results in all booster units being inoperative, the aircraft will still be adequately controllable, provided that the center of gravity is between 23-30 percent MAC. The control forces will, of course, be quite heavy, and the emergency elevator booster shift control should be pulled out to reduce the forces on the control wheel. This reduction in force is accomplished by a change in mechanical ratio and results in a corresponding reduction in the available elevator travel.

Flight Control Precautions.

Although the control forces for transport aircraft are, in general, heavier than in some other types, it is still possible to apply severe structural loads by a rapid and violent application, sudden release, or reversal of force on any of the three control systems. It is within the pilot's physical power to cause failure of some components of the airframe structure, particularly when flying at high speeds.

CAUTION

A rapid release or reversal of rudder force such as slips or rapid movement of rudder pedals can result in heavy loads on the vertical fins and aft fuselage, and therefore should be avoided.

BOOST-ON OPERATION.

Boosters should never be turned on at high speeds, or at any speed, if the aircraft is out of trim. Doing so will result in a rapid and severe application or release of forces on any system in which the boost is turned either off or on. In an emergency, the boost may be turned off at any airspeed. If conditions permit, however, the speed should be maintained between 130 and 155 knots during the changeover. Normal crusing speed schedules may be reestablished with boost off; however, an increase in control forces required may be expected. If the autopilot is engaged during boost-off operation the flight crew should monitor airplane attitude continually and more carefully than during normal operation, particularly during flight through turbulent areas. If gusts cause deviation from the trimmed attitude, the autopilot might become stalled due to increased air loads on the controls, so that action by the crew may be required to effect recovery.

Crosswind Effect.

Crosswind landing characteristics are excellent; however, airspeeds above 115 knots may be desirable in the approach, if gusty conditions exist, in order to maintain desired margins of aileron control response rate.

During gusty conditions always increase the takeoff, threshold, and landing speed by the full gust increment, but not to exceed 10 knots. The erratic characteristics of gusts, as to magnitude and direction of the wind, may result in a high relative airspeed reading, which may result in a dangerous situation, should the wind change direction or decay.

IN-FLIGHT CONTROL TECHNIQUE.

Pilots should strive for proper rudder-aileron coordination. This is particularly important in recoveries from highly banked conditions at slow speeds. If an attempt is made to roll out of such a highly banked condition using ailerons only, the low wing may not come up immediately and the aircraft will tend to scoop out toward the low side. This could be extremely hazardous at low altitudes.

LEVEL-FLIGHT CHARACTERISTICS.

Extensive flight tests of civilian and military versions of Super Constellation aircraft similar to the EC-121R indicate that it will be stable throughout its speed range. It can be flown from its maximum placard speed to the stall speeds without reversals or abnormal variations of control force. However, as is true of most aircraft, excellent piloting technique and smooth air are required in order to maintain steady flight speeds when power is reduced to settings recommended for holding and maximun endurance.

Figure 6-2 illustrates some typical speed-power characteristics at normal and slow flight speeds discussed in the following paragraphs.

SLOW FLYING.

There are two major differences between operating at slow and normal flight speeds. The most noticeable is the different ratio of speed change to power change. The aircraft becomes much more sensitive to small power changes as speed is reduced. A power adjustment which might normally result in a 2 or 3 knot speed change at high-speed cruise conditions can result in a 10 to 15 knot speed change in calm air at endurance speeds. The effects of turbulence are also much greater, and the speed change takes place over a longer period of time. Successive gusts, encountered before intermediate recovery is effected, might result in excessive slowing of the aircraft. Therefore, the pilot should exercise a more positive degree of control than would be considered normal for higher speed operation.

MINIMUM SPEED OPERATION

Minimum speed operation leads to the second difference between normal and slow-speed operation. There is a possibility of the aircraft flying on the back side of the power curve. An aircraft may be longitudinally stable throughout its speed range, as this aircraft is, and still experience what might seem to be airspeed instability in the slow-speed area of operation. This is a situation which can occur at low flight speeds with any aircraft having favorable lift/drag ratio and reasonable stall speeds. It is referred to either as "flying on the back side of the power curve" or "operating in the reverse command region." It happens when airspeed is reduced to less than the speed for minimum power required for level flight, most often when power settings in use are just sufficient to maintain holding or endurance speeds.

POWER REQUIREMENTS.

The power required for flight increases with decreasing speed after the minimum power point has been passed. The aircraft can then accelerate to a greater speed without loss of altitude only if a positive margin of power exists; that is, if power required at reduced speed does not exceed the power setting in use. If a positive margin does not exist, the airplane will tend to recover trim speed by descending and accelerating unless adversely affected by turbulence. Recovery can also be affected by increasing power at constant altitude provided speed loss has not progressed to the point where insufficient power is available to check deceleration. The fastest recovery can be made, of course, by combined descent and addition of power. The only danger involved lies in not recognizing that the aircraft is flying "on the back side of the power curve" as it occurs, and attempting to maintain altitude without increasing power. Deceleration may then continue until the lowering airspeed and high deck angle are noticed, pre-stall buffet is felt, or the aircraft enters a stall.

SPEED REQUIREMENTS.

Recommended speeds for maximum endurance shown in the Appendix Miles-Per-Pound curves are approximately 110 percent of the speeds for minimum power or absolute maximum endurance. This provides a margin of excess power for acceleration if speed reduction due to turbulence should occur, thus allowing normal operations to be conducted at endurance cruising schedules.

Use of slightly higher than scheduled power settings should forestall large speed losses in mild or moderate turbulence, and ample power is available from the four engines to check large decelerations. The characteristic effects of "flying around the hook" should be known and recognizable however. Inadvertent entry into a "reverse command region" during an emergency might affect aircraft performance so as to affect flight safety.

WEIGHT CONSIDERATIONS.

An example might be illustrated by considering an airplane operating at heavy weight with two engines inoperative, at an altitude just less than its rated power ceiling. It can maintain altitude and expect an increase in performance as fuel is consumed and weight decreased. If turbulence shows the airplane beyond the minimum power speed however, power required for flight might become more than available. The pilot must then sacrifice altitude by descending rapidly enough to increase speed to the original value, check the deceleration by use of maximum power, or both. Continued operation at the reduced speed might result in slower but continuous loss of much more altitude than would be required to accelerate to the original speed.

EFFECT OF WING FLAPS.

Operation with flaps extended decreases the speed for minimum power to some extent. However, the value of minimum power associated with the decreased speed is always greater than that for the clean configuration at its corresponding minimum power speed.

CRUISING FLIGHT.

Adequate data are presented in the Appendix to permit preparation of a wide variety of flight plans. It is suggested that the pilot consider use of the following techniques, however, as a means of obtaining maximum performance from the aircraft:

1. When entering a cruise condition from a climb speed which is less than that desired for level flight, maintain climb power after leveling off until the desired cruise speed is reached and then reduce to the desired cruising power. Airspeed will tend to increase thereafter as fuel is consumed if crusing power is held constant. The increase in speed relative to the decrease in weight is lessened as lighter weights are approached.

2. Flight characteristics in turbulent air are favorable, although, as would be expected the average airspeed will tend to be less than for the same power setting in calm air. Some loss of range results. If range is the primary consideration, the pilot will find that a slight increase of power will result in a more stable speed. The increase should be determined for the specific conditions existing by inspection of fuel economy data in the Appendix. No change of power setting should normally be necessary if maximum endurance is the primary consideration. Duration is a function of total fuel flow rather than average airspeed. However, power may have to be increased at the expense of fuel flow in turbulence if the average airspeed tends to become less than 90 percent of the value recommended for maximum endurance.

HIGH SPEED FLIGHT.

In general, high speed flight will be normal in all respects; that is, no compressibility effects will be noted at speeds up to the placarded dive speed.

DIVING.

In general, it is not necessary to observe any special precautions when diving, other than to observe the limit speeds and structural load factors described in Section V of this manual. Under these conditions, no high-speed compressibility effects will be encountered. The aircraft should be retrimmed manually with speed changes in the normal manner. When recovering from a dive attitude, the aircraft should be pulled out manually without changing trim. The pilot should not use excessive or rapid application of control forces in the recovery, to avoid possible structural damage to the aircraft.

EFFECT OF CENTER-OF-GRAVITY POSITION ON AIRSPEED.

The center-of-gravity cg position of an aircraft must be held within specified limits in the interest of stability and controllability. No further restriction of cg location is necessary. It has been found that some personnel may overdo a good thing by trying to operate their aircraft at an optimum cg. Arbitrary refinements made in an attempt to obtain maximum performance will have no practical effect on speed or range. There is no optimum cg except from a standpoint of locating it so as to minimize pilot effort in controlling the aircraft.

The effect of cg travel can be visualized by considering the attitude changes made by the aircraft and the results of moving the flight controls. Suppose an aircraft is stabilized in level flight with the cg near the forward limit, and that its equilibrium is disturbed by moving the cg quickly to the rear limit. The tail will go down if no control forces are applied. The stabilizer requires a greater angle of attack in order to support a larger percentage of aircraft weight. The aircraft will then climb (if engine power is unchanged), because of the higher angle of attack imposed on the wing, and speed will drop off. However, there is no need for changing the angle of attack of the wing. The trim tabs can be moved, changing the position of the elevator and the camber of the tail so that the additional load can be supported by the tail without a change in deck angle. If the trim tabs are adjusted so that the airplane does not climb, the speed will remain constant. The change in total airplane drag is really quite small.

BASIC SPEED-POWER CHARACTERISTICS
NORMAL OPERATION AT SEA LEVEL

MODEL: EC-121R
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-O

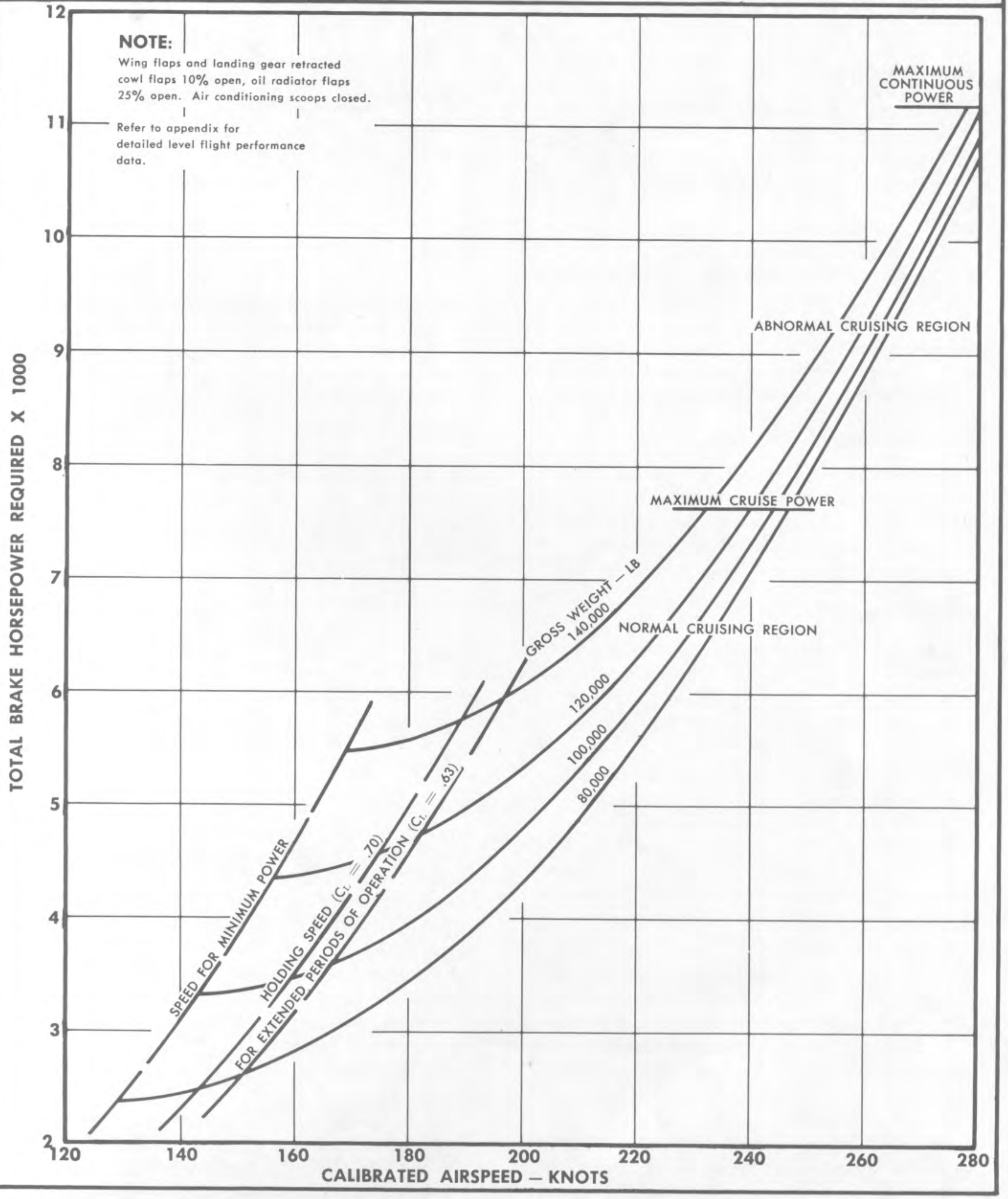

Figure 6-2 (Sheet 1 of 3)

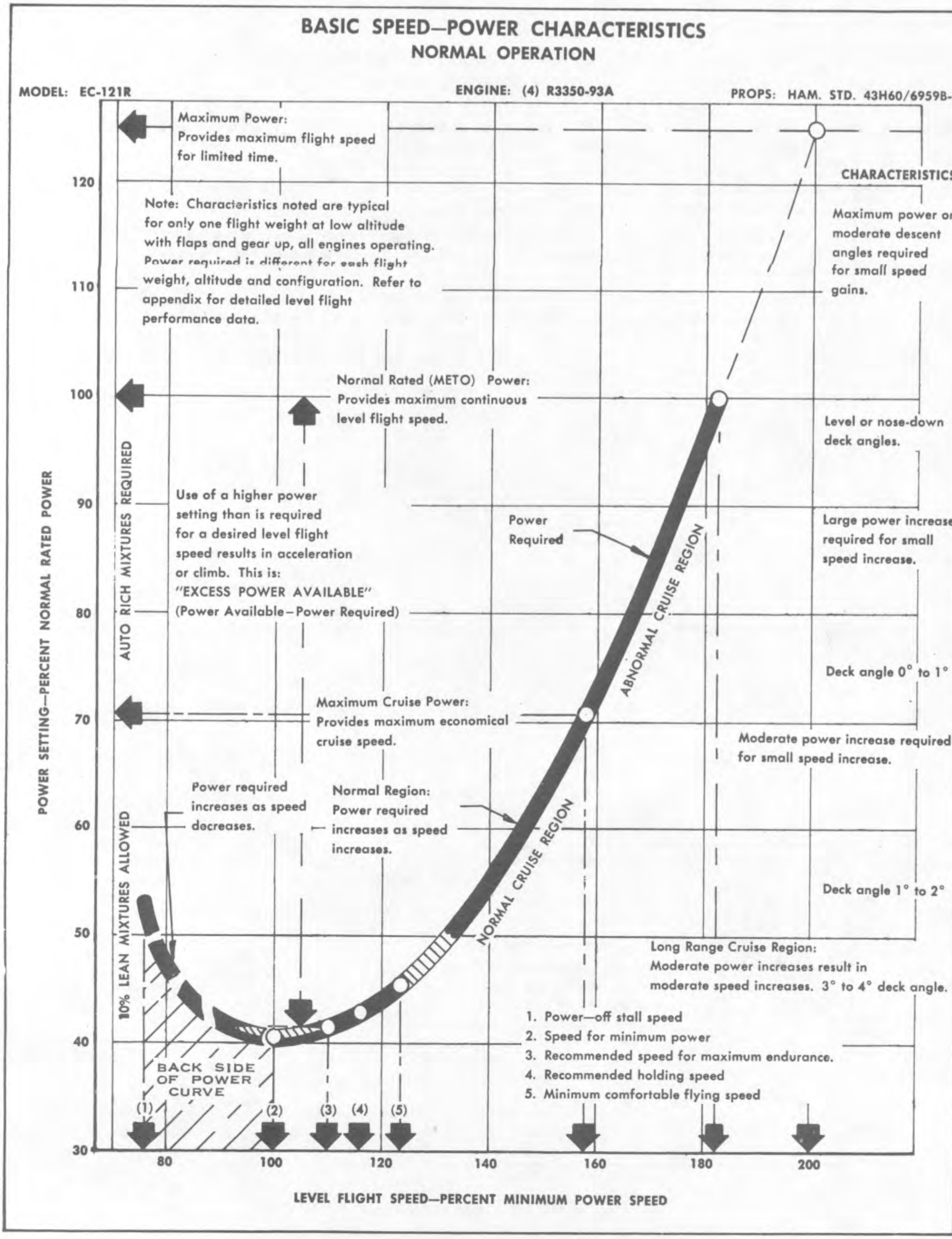

Figure 6-2 (Sheet 2 of 3)

BASIC SPEED—POWER CHARACTERISTICS
SLOW SPEED OPERATION

MODEL: EC-121R ENGINE: (4) R3350-93A PROPS: HAM. STD. 43H60/6959B-O

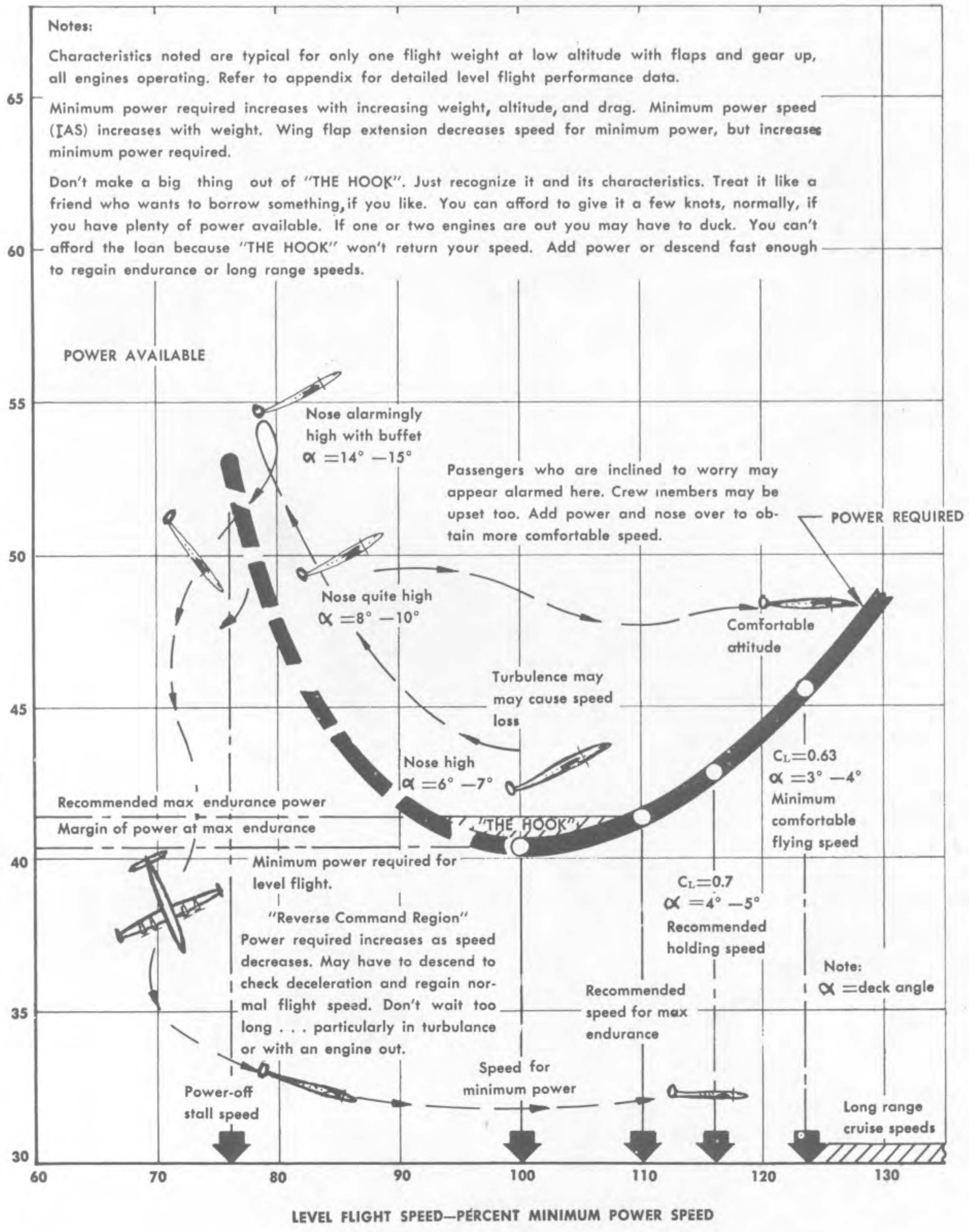

Figure 6-2 (Sheet 3 of 3)

Actually, calculations have been made which consider the drag of deflected tabs, drag of deflected elevators, and change in induced drag and downwash angle of the wing with changing cg. These calculations indicated that speed should change slightly—about 1 or 2 miles per hour. Attempts were made to prove this in flight with several aircraft, using men moving back and forth in the fuselage as ballast. No measurable effects of cg position on speed were found, although checks were made at various altitudes and weights, and from cruising to top speeds.

Tests were also conducted on a Super Constellation aircraft to determine the effect on center-of-gravity position on level-flight speed. Two complete sets of speed-versus-power data were obtained during a flight at 10,000 feet density altitude. Average gross weight was 110,000 pounds. Very precise runs were made with gear-up cg's of 17.7 percent and 32 percent, ballast installations being such that center of gravity could be shifted in flight. Results indicated that the aircraft was very slightly faster at the rearward cg position. At normal rated power the increment was 0.5 mph IAS. At maximum cruise power it was 1.0 mph IAS, and at long range cruise power it was 2.0 mph IAS.

The Super Constellation tests appear to show that pilots might realize a small speed improvement by operating at rearward rather than forward or intermediate cg positions. It should be realized, however, that the normal decrease in longitudinal stability at extreme aft cg positions requires very precise piloting technique in order to realize the speed improvement possible. Extremely calm atmospheric conditions must also exist. It will be most difficult to obtain any gains in mildly turbulent air with normal movement of the passengers and crew. Therefore, it can be stated that variation of cg within required limits will have no effect on speed or range of service aircraft in normal operation.

Pilots who insist on operating at optimum cg say this is necessary before the aircraft can be flown "on the step." This is another misleading term which should be better understood. Considering aircraft acceleration characteristics and the relationship between angle of attack (deck angle) and airspeed, it may take some time to accelerate from climb speed to cruise speed after climbing to altitude and leveling out for cruise. The increase in speed will generally be from 20 to 30 knots IAS. The rate of acceleration will depend on gross weight and power setting. The time required to reach a stabilized level flight speed may vary from 5 minutes to more than 20 minutes. Attitude will also change from a nose-up angle at the top of the climb to a more level angle as stabilized speed is reached. The change in deck angle will be fairly rapid at first, slowing as the stable speed is approached, and may create a false impression of being on a step of some sort. This step is merely the natural attitude taken by the airplane as speed increases. The wing is able to support the aircraft weight at a lower angle of attack. Any disturbance which then slows the aircraft will cause the wing to require a higher angle of attack and create the impression of being off the step. There really isn't any sudden transition to a "step" attitude as stable level flight speeds are attained.

However, the phrase "level flight" must be given some consideration also. Deviation from a level flight condition, even slightly, can have a very marked effect on speed. For instance, if an aircraft is trimmed precisely to level flight at long range cruise speed and the trim is then disturbed so as to give a 30 feet per minute rate of climb or descent, the speed increase (for dive) or decrease (for climb) will be about 5 knots. This is about 1 knot per 6 feet per minute. Thus, a small and perhaps unnoticed out-of-trim condition will cause a deviation in airspeed from the stable value for level flight. As explained previously, cg position will not cause this effect; it is due entirely to accuracy of trim.

The practice of climbing above and then letting down to cruising altitude may result in a trim condition which will give a slight descent, and therefore an IAS slightly higher than stabilized speed. The gain from this practice is doubtful in view of the higher fuel consumption in climb as compared to level flight.

It may be pointed out that an aircraft in level flight will decelerate faster than it will accelerate because of the shapes of the power-required and power-available curves. This holds true for all propeller-driven aircraft. Therefore, an aircraft which is dived to the cruise altitude will stabilize in less time than one which is accelerated to cruise speed in level flight. The speed difference while approaching stabilization is slight, and has a very minor effect on total range.

It has been suggested that the step may be the result of operating on the back side of the "hook" in the power-required curve. This is another case of misleading terms being combined. Examination of figure 6-2 shows that there is no relationship between normal cruising flight and operation of the back side of the "hook." Airspeed will be quite unstable on the back side of the "hook" unless the airplane is held at speed by climbing or descending.

Meteorological conditions, such as rising and falling air masses, can exist which may give you a realistic illusion of on- or off-the-step performance. If your aircraft is flying through a rising air mass, you may actually set trim for a slight rate of descent in endeavoring to maintain a constant altitude. This will result in a higher airspeed than normally would be attained with a given power setting.