HIGH SPEED DELTA aircraft, such as this B-58 and the Avro Arrow, have a marked nose-up landing attitude. This and their limited slow-speed control characteristics increase the need for greatly improved pilot aids, or automatic landing control.

Evolution in Landing Aids II

Meeting Critical Jet Needs

By Edward N. Hooton

Now resident in Canada, Mr. Hooton was formerly a flight test engineer with the Blind Landing Experimental Unit of the U.K. Ministry of Supply.

In North America, where the percentage of good flying weather is high, airport lighting systems have progressed little from the early lead-in type. However, at Andrews A.F.B., where the USAF is conducting intensive all-weather landing trials, the basic centre-line has been modified to include horizontal bars for roll guidance.

In an attempt to cut down the number of accidents due to undershooting, the point of origin of the GCA or ILS glide-slope has been moved farther down the runway. At the present time, it is about 1,000 feet from the beginning of the runway on most large airfields.

This, together with the poor downward view from some aircraft, means that at the low break-off heights, using ILS or GCA, the pilot will see very little of the approach lighting because most of it will have been passed over before transition occurs. He is therefore dependent upon the runway lighting pattern to provide him with all the guidance required to complete the landing.

Many airfields have only a runway flarepath consisting of sidelights little different than that used in the thirties. Some have "stub bars" added (horizontal bars of lights outside the side lights), which do give some roll guidance. These are of some value up to the beginning of the flareout, but there is a limit to the number of lights that can be positioned around the runway. If there are too many they accentuate the "black hole" effect and are virtually useless to a pilot below 50 feet as they merge together in a confusing jumble.

It is this "black hole" effect that must be eliminated and it seems certain that many runways to be built in the future will incorporate some form of flush lighting. Various widely differing patterns have been suggested, and very careful testing will be required before any universal system can be adopted. The arrangement and characteristics of such lights are very critical if we are to achieve the optimum pattern capable of giving direction and roll guidance in addition to providing some "built-in texture."

Fine-Weather Problems

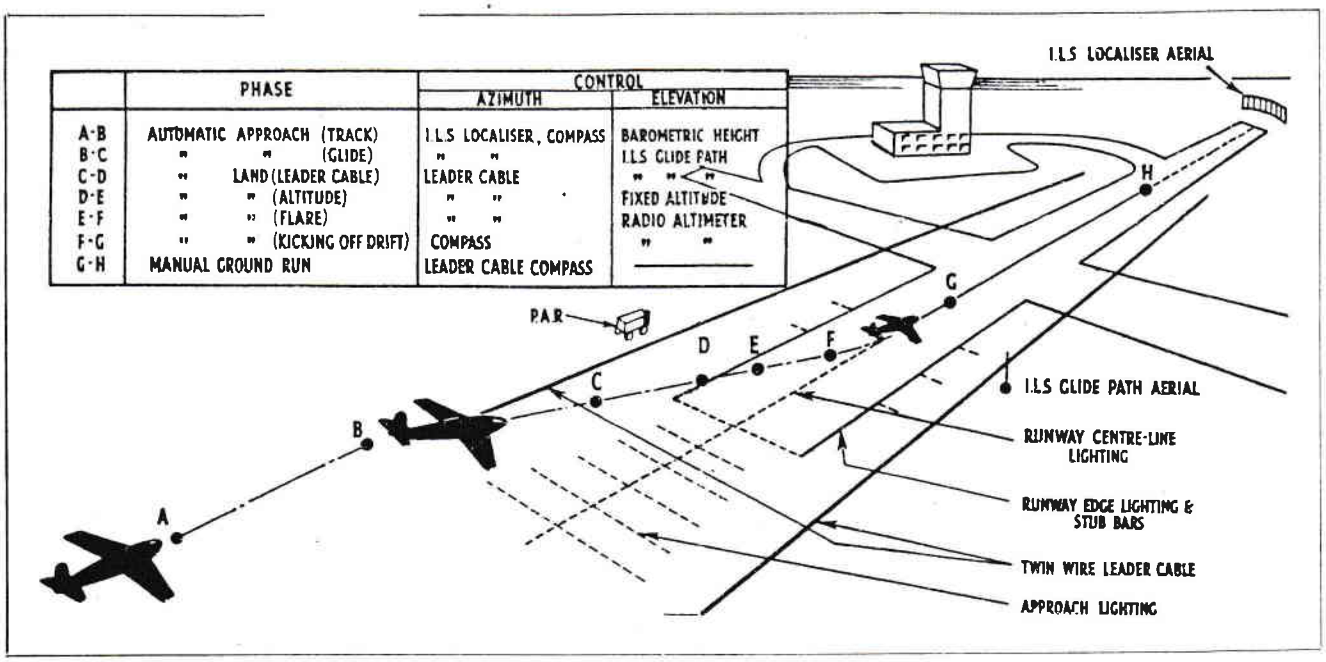
Before concluding this description of present-day techniques and requirements, the problems of Arctic "White-out" and the conditions under which accidents can occur in good weather, should be considered.

"White-out" occurs especially in flat snow-covered regions when 8/8 upper cloud is present and gives the effect commonly described as "flying in milk." All the visual cues necessary for landing are therefore removed completely. If we are to fully exploit the Arctic and Antarctic regions, extensive landing aids will be required for the aircraft operating there.

So far we have dealt only with the conditions peculiar to landing in bad weather, i.e. low cloud and poor visibility. However, it is a fact that many accidents do occur when landing in good weather, and far too many of them are traced to "pilot error."

There are a large number of factors which affect the precise judgments that a pilot must make when landing. Such things as contrast between runway and grass, lack of peripheral vision (i.e. limited field view in azimuth from the cockpit), the inability of the human eye to detect small changes in vertical height, the necessity of a good horizon indication, etc. A lack, or impairment of one or more of these can again lead to quite serious optical illusions which are accounted for by "pilot error" in the accident reports.

It is clear therefore that if we wish to operate in "zero-zero" conditions there is one of two things we must



	PHASE	CONTROL	
		AZIMUTH	ELEVATION
A-B	AUTOMATIC APPROACH (TRACK)	I.L.S LOCALISER, COMPASS	BAROMETRIC HEIGHT
B-C	" " (GLIDE)	" "	I.L.S GLIDE PATH
C-D	" LAND (LEADER CABLE)	LEADER CABLE	" " "
D-E	" " (ALTITUDE)	" "	FIXED ALTITUDE
E-F	" " (FLARE)	" "	RADIO ALTIMETER
F-G	" " (KICKING OFF DRIFT)	COMPASS	" "
G-H	MANUAL GROUND RUN	LEADER CABLE COMPASS	———

BLEU SYSTEM. This diagram shows the principles of the blind landing system developed in the U. K. *(Modern Transport sketch.)*

do. We must either improve the visual aids for the pilot, and give him the necessary time to act upon them, or we must make the landing completely automatic.

Accepting the fact that zero-zero landings are a must in the future, what is being done to accomplish them?

There are three ways of tackling the problem:

(i) Prevention, or dispersal of fog and cloud formation.

(ii) Completely automatic control of the aircraft during approach, flareout and landing roll.

(iii) Providing the pilot with some means of seeing through fog with radio or radar equipment in combination with improved flight instruments.

Wartime Fog Dispersal

Fog dispersal has been achieved by the use of heat, chemical reaction and ultrasonic sound waves.

The wartime use of "Fido" was a good example of the heating method. Gasoline burners were placed alongside the runway at intervals and the combined heat from these removed the fog from the runway area.

In Europe some small-scale experiments have also been conducted using a combination of chemical reaction and ultrasonics. These were moderately successful and proved economical, unlike "Fido", which was expensive. However, both entail complex ground installations which also constitute obstruction hazards near the runway. Research is being continued on these methods and may lead to a simple, inexpensive system in the future.

As described in the first part of this article the use of the autopilot has greatly increased the accuracy of the instrument approach. If, therefore, suitable landing aids can be provided, we shall be able to extend our flightpath to land completely under automatic control. In this era of increasing automation this is a logical step, and the advantages will be great when we consider the characteristics of future aircraft.

Because of high-speed heating effects and drag considerations, the pilot is likely to be "buried" inside his aircraft with little or no external vision. In designing an aircraft primarily for high speed in its operational role, a compromise must be made and so the low-speed characteristics will often be very poor by today's standards. Approach and landing speeds will increase and aerodynamic control problems will complicate the issue.

Problems With Deltas

Most tail-less delta aircraft, for instance, fly at very high angles of attack at their approach speeds, and this complicates both the control problem and the pilot vision requirements. Also the drag-speed characteristics of thin-wing aircraft, particularly those with swept surfaces, are very critical. With decreasing speed the drag curve drops rapidly to the minimum drag figure, but with a further decrease in speed it rises very sharply to the point of stall.

This means that accurate control of the aircraft is required on the approach to keep the correct flight path. This in turn means that the airspeed must be kept very close to the optimum, which is slightly above the minimum drag speed. A slight inadvertent reduction of airspeed will cause a rapid increase in drag and thus bring the aircraft well below the glide slope.

Regaining the correct flight path is difficult because an increase in engine power will not always have the desired effect of increasing the airspeed, due to the enormous amount of drag.

Preventative methods that can be applied are the use of high-lift devices such as jet flaps, leading edge flaps, etc., and the full use of automatic controls used in conjunction with accurate landing aids.

Considerable reseach on landing aids has been carried out since the war by both Britain and the U. S. A. With so much of this work covered by the veil of security, it is difficult to determine what has been done and what has yet to be achieved. However, some security releases and public statements on both sides of the Atlantic enable us to piece together some parts of the puzzle.

It appears Britain and the U. S. A. have used different techniques in their research. The basic difference between the two is that the British have developed a system which is basically an extension of the present automatic ILS concept.

Evidence of the British technique was given by Sir Arnold Hall in a lecture early in 1955, when he was Director of R.A.E., Farnborough. In the last year several other items of information have been released.

The system utilizes high precision ILS for automatic approach down to a breakoff height of about 200 feet

(Continued on page 40)

Practical Value of JANET

By George Glinski, P.Eng.

Only long-haired scientists would think of utilizing such a transient and unpredictable phenomenon as a meteor trail for reliable radio communications!

Effects of meteor bursts on radio communication were observed as early as in 1943 and reported in 1948. Following the war, radio propagation experts of many countries made a systematic study of ionization caused by meteors. By 1950 enough was known about meteor bursts to suggest their use in radio communication.

In Canada, Defense Research Board took the initiative and by 1954 had its first closed-loop meteor circuit in operation. Canadian development of this unusual radio communication technique would have been impossible without the existence of the information theory which, luckily, was being developed simultaneously in many places.

The meteor system utilizes high speed, wide-band communication with storage of information. As such it is a good example of practical application of the information theory. The system incorporating these techniques was christened JANET, after Janus, the Roman god of doors and gates, who looked both ways at once.

Efficient use of meteor trails for communication requires operation in bursts, taking advantage of strong signals when they are present. One advantage of this burst communication is the lower transmitter power requirement.

Control of the system is exercised by "gates" which allow the transmission of information only when the received signal is sufficiently high. This operation obviously requires the information storage at each end.

First successful operation of a two-way circuit (from Ottawa to Port Arthur, a distance of some 500 miles) took place in June of 1953 on frequencies of the order of 50 megacycles. The first high speed teletype transmission took place in March of 1954 between Ottawa and Halifax (with retransmission to Ottawa).

Meteor Characteristics

Our atmosphere is continuously bombarded by millions of small particles (10 billion in one day). When a particle enters the ionosphere it is heated by collision with air molecules. Its atoms evaporate and produce further collisions. As a result, the surrounding atoms are ionized and some even emit visible light.

This ionization produces a trail of free electrons in the wake of the meteor and this trail may affect the propagation.

In addition to these always present "background" meteors, there are meteoric showers when the earth goes through streams of particles traveling in well-defined orbits about the sun.

The ionized trails partially scatter any radio waves falling on them and this effect is used in the JANET system for communication. The scattering of radio waves by meteors has been studied for many years and several Canadians (D. W. R. McKinley from NRC, for instance) made important discoveries.

Why JANET

Why the Canadian enthusiasm on the JANET system? First, there is the pride of developing a novel and reliable communication technique based on such "unreliable" phenomenon as meteor trails.

Second, Canada, with its sparsely populated North divided by the auroral zone, has a general requirement for a low power, reliable, point-to-point communication system for ranges in the order of 250-750 miles. JANET, even at this early stage could fill this need.

The only competitive system of uhf communication, *ionospheric scatter*, has the disadvantages of more power, larger antennas, more interference, less privacy and narrower spectrum. It should be pointed out, however, that meteor-burst communication systems require more complex equipment and involve greater delays in starting messages.

The JANET system was developed by a group of DRB scientists under P. A. Forsyth of the Radio Physics Laboratories at Shirley Bay, near Ottawa. After DRB has established the feasibility of the method, a contract was placed with Ferranti Electric Ltd. of Canada for the development of JANET type of equipment. This equipment has been now in operation for almost three years.

Landing Aids II

(Continued from page 38)

at a range of 1,500 yards from touchdown. From this point azimuth guidance is provided by leader cables and height is obtained from a very precise altimeter.

The leader cable principle is not new but this particular application is. Two cables carrying an electric current are laid out parallel on either side of the runway, extending out to 1,500 yards. The relationship of the two magnetic fields radiated by the cables can be sensed by an aerial in the aircraft to give lateral error. This, together with the radio height, is fed to the computor element of the autopilot. The computor converts the data into control output to keep the aircraft on the centre line, and below the correct height for the commencement of the flareout. The rate of descent is then progressively reduced.

In experiments carried out at the Blind Landing Experimental Unit on Canberra and Varsity aircraft, some 450 completely automatic landings have been achieved with an average vertical velocity at touchdown in the order of two feet per second and lateral errors of up to five feet from the runway centreline. The leader cables can be extended along the runway and taxi-strip to provide guidance for taxi-ing in zero-zero conditions.

American Methods

The Americans have done work on these lines, using radar altimeters and accelerometers, for retrieving missile test vehicles. But their major development for manned aircraft has been the Bell Automatic Landing System. This is a highly sophisticated automatic CGA equipment in which the operators and controller have been replaced by an analogue computor.

The position of an aircraft relative to the centreline and glide slope is measured accurately by the radar, fed to the computor, which then transmits corrections to the aircraft by radio link. No special equipment is required in the aircraft, apart from automatic speed control, the incoming signals being fed to the autopilot in the normal way.

The system was originally developed for the U. S. Navy for deck landings but the U. S. A. F. now has an interest in the program. In a recent demonstration it was stated that the system was flexible enough to handle anything from a Boeing 707 to a Piper Cub.

(To be continued)