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TIMED APPROACHES AND UTILIZATION OF RADAR IN SPACING OF AIRCRAFT ON FINAL APPROACH

(Reduction of Intervals between Successive Approaches and Landings)

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F O R E W O R D

The purpose of ICAO Circulars is to distribute information bearing upon the progress of ICAO's work more widely than would be possible for the ordinary series of documents.

The present circular publishes informative material, drafted by the fourth session of the RAC Division (November - December 1950), on two possible methods which can be used to reduce the time interval between successive approaches and landing.

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PART I

TIMED APPROACHES

1. PREAMBLE

1.1 Increasing air traffic is creating congestion at many aerodromes throughout the world during IFR weather conditions. This congestion is resulting in excessive delays to arriving aircraft awaiting their turn to land or in the diversion of the aircraft to a less congested aerodrome at great inconvenience and cost to passengers and the operator.

1.2 This problem does not exist to any appreciable extent during periods in which aircraft can execute their entire approach to an aerodrome in accordance with Visual Flight Rules, since traffic separation is not required nor is it necessary to execute the complicated manoeuvres associated with an instrument approach. During such weather conditions, aircraft can be landed at intervals of only a little longer than the time required for an aircraft to travel from the point of touch-down to the point at which it clears the runway. At locations where adequate runway turn-offs exist, aircraft can be landed at intervals of approximately one minute.

1.3 When aircraft cannot approach an aerodrome in accordance with VFR, however, it is necessary that traffic separation be provided to aircraft by an air traffic control service unit and that aircraft follow a predetermined path which will provide appropriate terrain clearance during the descent to the aerodrome. These approach paths are established for each aerodrome at which instrument operations are contemplated and are, in general, based on criteria contained in Part V of the Final Report of the Operations Division, Third Session. These flight paths are known as "Instrument Approach Procedures" and specify the flight path to be used with the various types of landing aids. At aerodromes where more than one type of landing aid is in operation, an "instrument approach procedure" is established for use with each facility, such as "ILS," "BABS," "RADIO RANGE," etc. The aircraft

manoeuvres associated with each of the procedures are somewhat different, since some require an "initial approach", an "intermediate approach" and a "final approach," whereas other procedures specify only the "initial" and "final" approaches.

1.4 The time consumed by an aircraft in executing an instrument approach procedure varies considerably. For the purpose of illustration, the time required for the execution of an instrument approach using present procedures (from arrival over the terminal navigation aid at initial approach altitude to arrival over this aid on final approach) will normally be as follows:

a) Intermediate approach - outbound track from the terminal navigation aid - four minutes.

b) Procedure turn - reversal of course from outbound track to inbound track - two minutes.

c) Final approach - return to navigational aid on inbound track in line with axis of runway - four minutes.

It can be seen from the above that a total of at least ten minutes is required for the execution of a full instrument approach.

1.5 Due to the many manoeuvres associated with an instrument approach as illustrated above and the lack of knowledge by the air traffic control service unit as to the exact location and altitude of the aircraft during intermediate and final approach, only one aircraft can be cleared for an approach at a time. The use of such instrument approach procedures, therefore, limits the capacity of an aerodrome to approximately six aircraft per hour.

1.6 Many aerodromes have a traffic density in excess of six aircraft per hour during inclement weather conditions and since only six aircraft can be accepted, the time limitation imposed by the instrument approach procedure results in delay to arriving aircraft. Since the aircraft acceptance rate of a runway during good weather conditions is far in excess of that during bad weather when full instrument approach procedures must be executed, it is necessary to develop procedures for use at these aerodromes which will make it possible to decrease the interval between approaches.

1.7 Procedures have been developed by the United States to accomplish this result and have been in use for several years. These procedures utilize the "final approach" portion only of the full instrument

approach procedure, together with improved and precise air traffic control procedures. Two different methods are employed, i.e., vertical separation procedures and longitudinal separation procedures, the application of which requires:

1) Instantaneous and direct two-way communication between the controller and the pilots.

2) Adequate navigational aids for instrument approach and holding purposes, including

a) a navigational aid serving the instrument runway,

b) a navigational aid providing a holding point or "gate" on the approach course.

3) An approved instrument approach procedure, utilizing the "final approach" portion only.

1.8 Application of the "vertical" separation procedure provides standard vertical separation between all aircraft in an approach sequence, without regard to their position in relation to the "gate". When the first aircraft in the sequence has reported in visual reference to the ground, the second aircraft is released from his assigned altitude to descend for landing. When the second aircraft reports vacating his flight level, the third aircraft is cleared to descend to the vacated level and to pass the "gate", etc.

1.9 The application of the "longitudinal" separation procedures provides altitude separation between all holding aircraft outside the "gate" and only longitudinal (time) separation between aircraft on final approach between the "gate" and the runway. The outer marker of an ILS is considered as being a "gate", since this procedure generally is used at locations served by an Instrument Landing System.

1.10 In the use of either "vertical" or "longitudinal" separation procedures, pilots are instructed to leave the "gate" at a predetermined time. The interval between these times is variable and is determined by the controller on the basis of current local conditions, such as weather, relative speed of the aircraft, and distance of the "gate" from the airport. The application of either of these procedures should make it possible, under normal conditions, to reduce the interval between successive approaches to approximately three minutes; however, their use requires the issuance of precise air traffic control instructions directly to the pilot and precise adherence thereto.

2. TERMINAL AREA AIR TRAFFIC CONTROL PROCEDURES EMPLOYING DIRECT COMMUNICATION BETWEEN APPROACH CONTROLLERS AND PILOTS

2.1 INTRODUCTION

The procedures contained herein are for use in units providing approach control service to aircraft by communicating directly with pilots over two-way radiotelephone channels.

2.1.1 Coordination of arriving and departing traffic is effected by the approach controller, who normally is in a position to see the aerodrome and aircraft in the vicinity and is able, therefore, to take advantage of every opportunity to expedite the flow of traffic on and around the aerodrome.

2.1.2 The operational requirements for implementing these procedures are:

a) an adequate navigational facility for instrument approach and holding purposes,

b) established instrument approach procedures,

c) one or more radio channels available to the approach controller for direct communication with the pilot.

2.2 COORDINATION

The control of IFR traffic shall be coordinated between units providing approach control service and area control centres as follows:

2.2.1 The centre shall clear aircraft to a holding point, including in such clearance holding information and expected approach time. The unit providing approach control service shall assume control of the aircraft at a point (time or fix) established by agreement, or earlier if specified in an air route clearance.

2.2.2 The centre shall provide separation between all aircraft within a control area, except that the unit providing approach control service shall:

a) maintain separation between all arriving aircraft under its jurisdiction, and

b) provide separation between departing aircraft and between departing aircraft and all other aircraft under its jurisdiction.

2.2.3 The control of aircraft which are holding at more than one holding point may be effected by a unit providing approach control service, provided the division of control between the centre and such unit is basically consistent with the above procedures.

2.2.4 If it is considered essential, due to the position of holding points or for other reasons, an area may be established wherein the control of traffic normally will be effected by a unit providing approach control service. Designation of such an area, however, shall not preclude release of aircraft to a unit providing approach control service prior to its reaching the boundary thereof, if traffic can be expedited thereby.

2.3 TAKE-OFF PROCEDURES

An approach controller may, at his discretion, authorize immediate take-off with less than standard separation:

2.3.1 When the arriving aircraft is in sight; or

2.3.2 Until an arriving aircraft which is making a straight-in approach reports leaving a holding point which is not less than four miles from the aerodrome; or

2.3.3 When an arriving aircraft which is making a visual approach reports over a visual reporting point which is not less than four miles from an aerodrome; or

2.3.4 Until an arriving aircraft which is in radar contact and positively identified is observed to be not less than two miles from the aerodrome.

2.4 COMMUNICATIONS PROCEDURES

2.4.1 General. Under these procedures, aircraft are cleared by the centre to a holding point with appropriate holding information. Clearances to hold "UNTIL FURTHER ADVISED BY (name of) APPROACH CONTROL ON (frequency)" are included so that the pilot will know on which frequency he will receive further clearances.

2.4.2 Procedures by Pilots. After release to a unit providing approach control service, pilots are expected to make the following reports to such units:

a) the time and altitude of reaching the holding point to which cleared, or at an earlier time if such time has been specified in his clearance;

b) when vacating any previously assigned flight level for a newly assigned level;

c) when leaving any assigned holding point;

d) when visual reference to the ground is established;

e) when an approach has been missed, requesting further clearance.

2.4.3 Communications Channels.

a) Pilots are expected to maintain communication by listening on the approach control frequency until cleared to change to the aerodrome control frequency or the appropriate ground control frequency.

b) Clearances to departing aircraft (taxi clearances, wind direction and velocity, time check, altimeter setting, runway number, air traffic control clearance, etc.) but not including take-off clearances, will normally be issued by the tower on the appropriate ground control frequency. For take-off clearance the pilot will normally communicate with the tower on the appropriate airborne VHF frequency.

2.5 BASIC CONTROL PROCEDURES

2.5.1 A radio fix (ILS outer marker, non-directional beacon, fan marker, etc.) located in the terminal area may be utilized as a holding point.

Aircraft are stacked vertically at successive 1000-foot levels, the lowest holding level being at least 1000 feet above the terrain or obstructions.

2.5.2 Arriving aircraft will be cleared by the appropriate centre to hold at an assigned altitude at a holding point serving the terminal area. Thereafter, the unit providing approach control service shall assume control of such aircraft, provided they have been released to approach control.

Note.- The approach control office will normally assume control of arriving aircraft at a designated point of changeover after coordination has been effected between the air traffic control units concerned.

2.5.3 In the event that position over the holding fix cannot be determined by the pilot, an amended clearance will be issued by the approach control unit.

2.5.4 When the reported ceiling is below the initial approach altitude authorized over the radio navigational facility at the point of intended letdown, the reported ceiling and visibility shall be included by the unit providing approach control service in the initial transmission to the aircraft and revised as necessary.

2.5.5 When the reported visibility at the point of intended landing is at or below the highest visibility minimum for the aerodrome or less than one mile, whichever is higher, the reported ceiling and visibility shall be included by the unit providing approach control service in the initial transmission to the aircraft and revised as necessary.

2.6 APPROACH CONTROL PROCEDURES - VERTICAL SEPARATION

2.6.1 General.

a) These air traffic control procedures are designed to increase the frequency of arrivals and are applicable to locations provided with a fan marker, non-directional radio beacon, or other navigational facility properly located along the final approach course to an aerodrome. The aircraft are held at the fan marker or other suitable holding point and are provided with 1000 feet vertical separation.

b) Standard vertical separation is provided between all aircraft until an approach is commenced. Vertical separation is then dependent upon the difference in lowest holding altitude and the final approach altitude.

2.6.2 Application.

a) The lowest holding altitude permissible at the holding point shall normally be utilized as the base of the stack of holding aircraft.

b) Each pilot in the approach sequence shall be given advance notice as to the time he should leave the holding point on approach to the aerodrome. The pilot then arranges his flight path so as to leave the holding point at the designated time. Departure is made at the designated time without further clearance from the unit providing approach control service, maintaining the last assigned altitude.

c) The first aircraft leaves the holding point at the time designated and commences descent when cleared for a straight-in approach to the aerodrome. Normally, the clearance to land shall be issued at the time the aircraft reports visual reference to the ground or is sighted by the unit providing approach control service.

d) The second aircraft shall be instructed to descend to the altitude previously held by the first aircraft after the first aircraft has reported vacating that altitude and leaving the holding point inbound.

e) The second aircraft shall be instructed to leave the holding point at a specified time (determined by the shortest time interval between approaches that the controller considers practicable) and to maintain the last assigned altitude. This aircraft shall then be cleared for an approach (descent) when the preceding aircraft is sighted by the unit providing approach control service and reasonable assurance exists that a normal landing can be made. In some instances, approach clearance may be issued a minute or two after the aircraft has departed from the holding point.

f) The aircraft at the lowest holding altitude need not be held at the holding point until the preceding aircraft is in sight, but should be given a departure time which will allow the pilot to proceed toward the terminal navigational facility (maintaining his altitude) and make a normal descent to the aerodrome after approach clearance is received.

Note 1.- This procedure will shorten the time interval between successive approaches.

Note 2.- If clearance for approach is not received in sufficient time to permit normal descent, aircraft are expected to maintain the last assigned altitude to the terminal radio navigational facility and request further clearance.

g) Determination of the time interval to be used between successive aircraft making final approach shall be based on the speed of the aircraft, prevailing weather conditions and distance from the holding point to the aerodrome. If the aircraft will arrive over the terminal navigational facility in IFR weather conditions, an additional minute may be added to the minimum time interval to allow the pilot one minute of level flight prior to crossing the terminal navigational facility. If weather conditions are such that the pilot is liable to encounter difficulty in completing his landing, however, the time interval shall be increased sufficiently to allow the first aircraft to land before the second aircraft is cleared for approach.

h) Succeeding aircraft shall be cleared to descend when the next lowest altitude level has been reported vacated.

2.6.2.1 Missed Approaches. When a unit providing approach control service becomes aware of a missed approach, the centre shall be advised immediately and subsequent action coordinated between the centre and such unit.

Note.- In the event of missed approach, the pilot is expected to follow the missed approach procedure, climbing to missed approach altitude on the appropriate track and requesting further clearance. (Succeeding aircraft of the sequence which have departed from the holding point would be required, under these circumstances, to maintain their assigned altitudes and hold between the terminal navigational facility and the holding point and request further clearance.)

2.6.2.2 Examples of Phraseologies. Approach Control Procedures with Altitude Separation:

a) Clearance to Holding Point - Clearance of aircraft to a holding point (Edgewood) by an area control centre for approach control purposes would be given in the following manner:

> "CESSNA 1234 CLEARED TO EDGEWOOD, MAINTAIN 3000, HOLD WEST OF EDGEWOOD UNTIL ADVISED BY SMITHVILLE APPROACH CONTROL 118.3 MEGACYCLES. EXPECT APPROACH CLEARANCE AT 16.12."

b) The pilot would report his arrival over the holding point to the approach controller in the unit providing approach control service as follows:

"SMITHVILLE APPROACH CONTROL THIS IS CESSNA 1234, OVER EDGEWOOD 15.57 AT 3000, OVER."

c) The approach controller would acknowledge over the appropriate frequency, giving current ceiling and visibility (if required), altimeter setting, time check, and further clearance as necessary.

2.6.2.3 Examples of Control Problem and Phraseologies. Assume that three aircraft, Navy 1615 at 2000 (#1), Air Force 1234 at 3000 (#2), and Beechcraft 5678 at 4000 (#3), have arrived at the holding point (Edgewood) and have reported to the approach controller. Final approach altitude in this case is 1000 feet. Clearances and reports would be as follows:

Time	Identification	Clearances or Reports
16.00	Approach Control	Navy 1615 cleared for straight-in approach to aerodrome, runway 36, wind North 8. Note.- Landing clearances should be combined with the approach clearance whenever possible to reduce the number of communication contacts with the pilot. Examples: (Aircraft Identification) cleared for (ILS-BABS-ETC.) approach and straight-in landing, runway 36, Type wind North 8, etc.
16.02	Navy 1615 (#1)	Leaving Edgewood and 2000 at 02.
16.02	Approach Control	Air Force 1234 descend to 2000 immediately, maintain 2000, depart Edgewood inbound at 16.07.
16.02	Air Force 1234 (#2)	Leaving 3000.
16.03	Approach Control	Beechcraft 5678 descend to 3000 immediately, maintain 3000, depart Edgewood inbound at 16.12.
16.03	Beechcraft 5678 (#3)	Leaving 4000.
16.07	Air Force 1234	Leaving Edgewood at 07. Maintaining 2000.

Time	Identification	Clearances or Reports
16.08		(Navy 1615 is sighted by approach control office and cleared to land).
16.08	Approach Control	Air Force 1234, cleared for straight-in approach to aerodrome, runway 36, wind North 8.
16.09	Air Force 1234	Leaving 2000.
16.09	Approach Control	Beechcraft 5678 descend to 2000 immediately, maintain 2000.
16.09	Beechcraft 5678	Leaving 3000.
16.12	Beechcraft 5678	Leaving Edgewood at 12, maintaining 2000.
16.13		(Air Force 1234 is sighted by approach control office and cleared to land)
16.13	Approach Control	Beechcraft 5678, cleared for straight-in approach to aerodrome, runway 36, wind North 8.
16.13	Beechcraft	Leaving 2000.
16.18		(Beechcraft 5678 sighted by approach control office and cleared to land).

Note.- In the above example, although each aircraft required six minutes to proceed from the holding point to the aerodrome (in sight of the unit providing approach control service), the interval between successive approaches was only five minutes. The aircraft at the lowest holding altitude need not be held at the holding point until preceding aircraft is in sight.

2.6.3 Approach Control Procedures - Longitudinal Separation.

2.6.3.1 Utilization of "Timed Approaches".

2.6.3.1.1 A fan marker located on the approach course of the radio range, the ILS outer marker/compass locator, or other holding points on the approach course may be utilized as a holding point for timed approaches.

2.6.3.1.2 Longitudinal separation during the approach shall be used only when:

a) Satisfactory communication is established and maintained between aircraft and the approach controller; and

b) Alternate missed approach procedures are available, or in lieu thereof, a sliding scale of ceiling and visibility combinations established for each location, below which timed approach procedures shall not be employed due to the probability of missed approaches; and

c) Regular or alternate missed approach procedures do not involve reversal of course.

2.6.3.1.3 When the requirements of 2.6.3.1.2 cannot be met, vertical separation shall be used.

2.6.3.1.4 The application of timed approach procedures necessitates accurate timing by pilots; therefore, each pilot in the approach sequence shall, prior to descent to the lowest holding altitude, be given a time check and notified of the time he is to leave the holding point inbound on his approach.

2.6.3.2 Normal Control Procedures.

Note.- The first aircraft will leave the holding point at the time designated and will commence descent for a straight-in approach to the aerodrome.

a) The second aircraft shall be given a time check and cleared to descend to the altitude previously held by the first aircraft after the first aircraft has reported vacating that altitude, and be instructed to leave the holding point inbound at a specified time (determined by the shortest time interval considered practicable between approaches). The second aircraft should not be held at the holding point until the landing of the first aircraft is assured if adequate separation will exist during the approach.

b) The third and succeeding aircraft in the sequence shall be cleared to descend to the next level when preceding aircraft have reported vacating the lower altitudes.

c) The time interval to be used between successive approaches shall be determined by the approach controller, depending upon the speed of the aircraft, existing weather conditions, the distance from

the holding point to the aerodrome and type of approach. Under optimum conditions, a two-minute interval shall be the absolute minimum; this interval being increased as necessary in poorer weather conditions, or because of high speed aircraft following slower speed aircraft.

d) The utilization of Timed Approach Procedures to expedite straight-in approaches from a holding point shall not compromise the arrival sequence of other aircraft which will execute a different type of instrument approach. For example, the timed approach sequence at an ILS outer marker shall be interrupted whenever necessary to permit an aircraft holding at the range station to commence a range approach in the established arrival sequence.

2.6.3.3 Missed Approaches:

a) Locations where alternate missed approach procedures are not available. When weather conditions approach the minimums established for time approaches, the interval between successive aircraft should be increased sufficiently to ensure that the third aircraft in the sequence (at the second holding level) will not be given an approach clearance and cleared to the lowest holding altitude until the landing of No.1 is assured.

Note 1.-This is necessary since the second aircraft must be returned to the holding point in the event the first aircraft misses the approach.

Note 2.-Strict adherence to the sliding scale minimums referred to in paragraph 2.6.3.1.2 should preclude the possibility of missed approaches.

b) Locations where alternate missed approach procedures are available. When weather conditions are such that the possibility of missed approaches exists, the approach clearance to alternate aircraft in the sequence shall specify the alternate missed approach procedure. In the event an aircraft misses an approach, the succeeding aircraft may be permitted to continue its approach, if already inbound from the holding point. All other aircraft should then be held at their assigned altitudes at the holding point until the first two are no longer a factor.

2.6.3.4 Example of Control Problem and Phraseologies. Assume that three aircraft, Navy 1615 at 2000 (#1), Air Force 1234 at 3000 (#2), and Beechcraft 5678 at 4000 (#3) have arrived at the holding point (Edgewood) and have reported to the approach controller. Lowest holding altitude is 2000 feet; interval three minutes. Clearances and reports would be as follows:

Time	Identification	Clearances or Reports
16.00	Approach Control	Navy 1615 cleared for straight-in approach to aerodrome, runway 36, wind North 8. Note.-Landing clearance should be combined with the approach clearance whenever possible to reduce the number of communication contacts with the pilot. Example: (Aircraft Identification) cleared for (ILS-BABS-ETC.) approach and straight-in landing, runway 36, Type wind North 8, etc.
16.02	Navy 1615 (#1)	Leaving Edgewood and 2000 at 02.
16.02	Approach Control	Air Force 1234, the time is now 16.02*, cleared for straight-in approach to aerodrome, descend to 2000 immediately, depart Edgewood inbound at 16.05.
16.02	Air Force 1234 (#2)	Leaving 3000.
16.03	Approach Control	Beechcraft 5678, the time is now 16.03, descend to 3000 immediately.
16.03	Beechcraft 5678 (#3)	Leaving 4000.
16.05	Air Force 1234	Leaving Edgewood and 2000 at 05.
16.06	Approach Control	Beechcraft 5678 cleared for straight-in approach to aerodrome, descend to 2000 immediately, depart Edgewood inbound at 16.08.
16.06	Beechcraft 5678	Leaving 3000.
16.07 1/2		(Navy 1615 is sighted by approach control office and cleared to land).

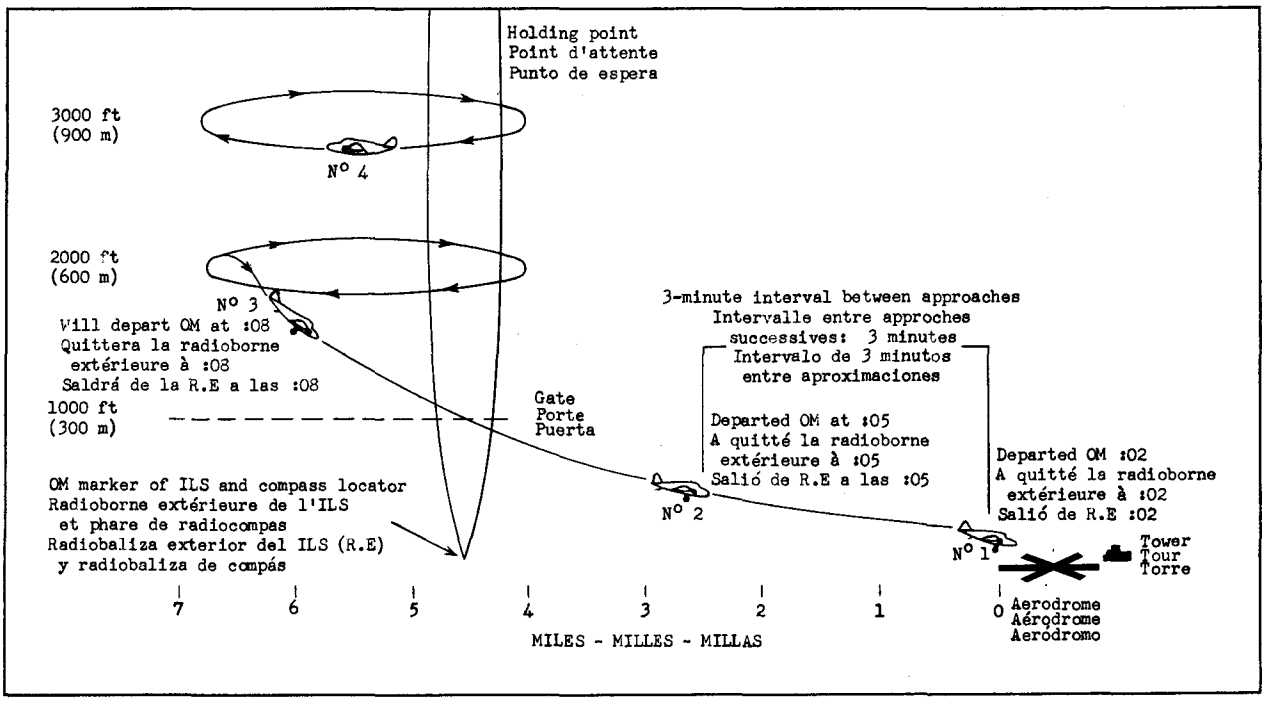
* Time check omitted if previously given.

Time	Identification	Clearance of Reports
16.08	Beechcraft 5678	Leaving Edgewood and 2000 at 08.
16.11		(Air Force 1234 is sighted by approach control office and cleared to land).
16.14		(Beechcraft 5678 is sighted by approach control office and cleared to land).

Note 1.- Altimeter setting, weather, etc., omitted from example for brevity.

Note 2.- In the above example, although each aircraft required six minutes to proceed from the marker to the aerodrome (in sight of the unit providing approach control service), the interval between successive approaches was only three minutes.

FIGURE 1 - FIGURA 1



APPROACH PROCEDURES
"TIMED APPROACHES"

The above diagram illustrates the application of time separation principles to an approach sequence, with the ILS outer marker as the holding point and gate. A compass locator normally is established at the OM site for navigation and positive identification. Using an interval of three minutes between successive approaches, the controller has cleared the Nos. 1, 2 and 3 aircraft to leave the marker inbound on approach at three-minute intervals. After aircraft in the approach sequence depart the holding point inbound, no altitude separation is provided, longitudinal separation being utilized.

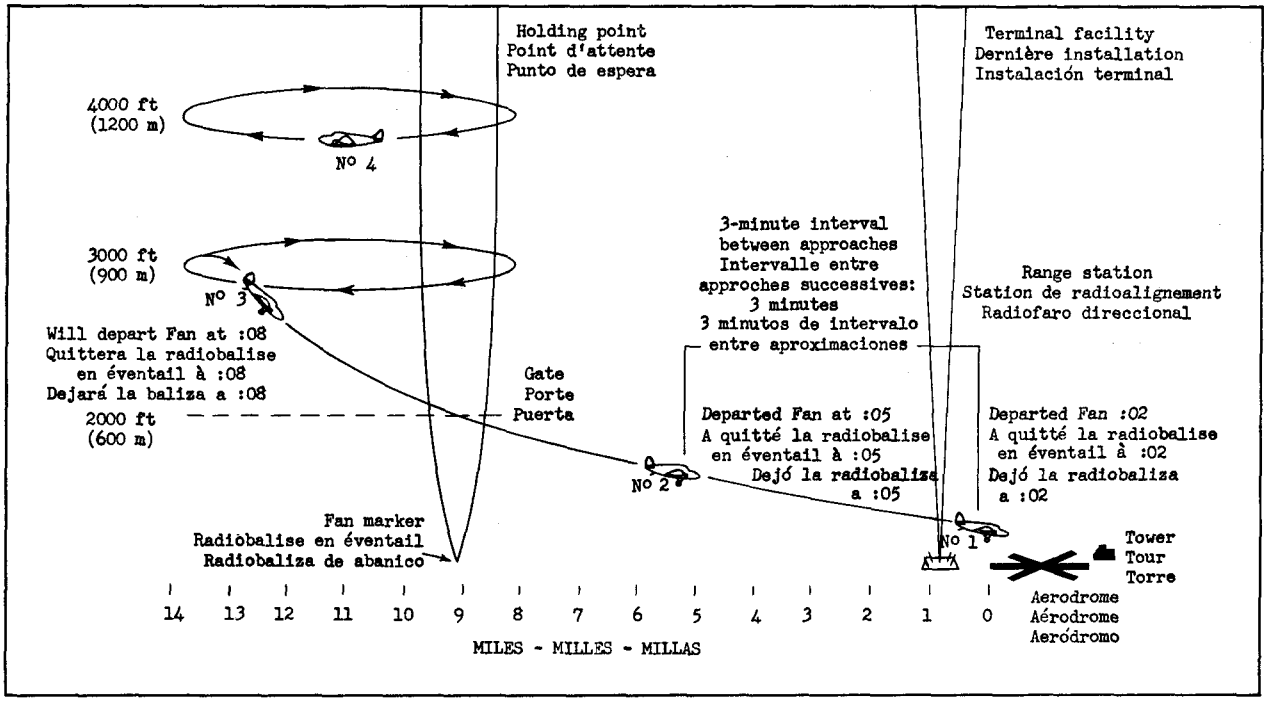
PROCEDURES D'APPROCHE
"APPROCHES MINUTEES"

Le schéma ci-dessus représente l'application des principes d'espacement dans le temps pour des approches successives lorsqu'on utilise la radioborne extérieure d'un ILS comme point d'attente et comme porte. Un phare de radiocompas pour la navigation et l'identification est situé à l'emplacement de la radioborne extérieure. En respectant un intervalle de trois minutes entre approches successives, le contrôleur a autorisé les aéronefs nos 1, 2 et 3 à quitter la radioborne pour effectuer leur approche à trois minutes d'intervalle. Lorsque les aéronefs ont quitté la position d'attente pour l'approche, l'espacement vertical est remplacé par l'espacement longitudinal.

PROCEDIMIENTOS DE APROXIMACION
"APROXIMACIONES SINCRONIZADAS"

Este diagrama ilustra la aplicación de los principios de separación de tiempo a las fases de aproximación, con la radiobaliza exterior ILS como punto de espera y puesta. La radiobaliza de compás de coloca, por lo general, en el emplazamiento de la radiobaliza exterior para la navegación e identificación positiva. Utilizando un intervalo de tres minutos entre las aproximaciones sucesivas, el encargado del control ha autorizado a las aeronaves Núms. 1, 2 y 3, para que abandonen la radiobaliza, con dirección a la aproximación, a intervalos de tres minutos. Después de que las aeronaves en el orden de aproximación salen del punto de espera, no se establece ninguna separación de altitud, utilizándose la separación longitudinal.

FIGURE 2 - FIGURA 2



APPROACH PROCEDURES
"TIMED APPROACHES"

The above diagram illustrates the application of time separation principles to an approach sequence. Using an interval of three minutes between successive approaches, the controller has cleared the Nos. 1, 2 and 3 aircraft to leave the marker inbound on approach at three-minute intervals. After aircraft in the approach sequence depart the holding fix inbound, no altitude separation is provided, longitudinal separation being utilized.

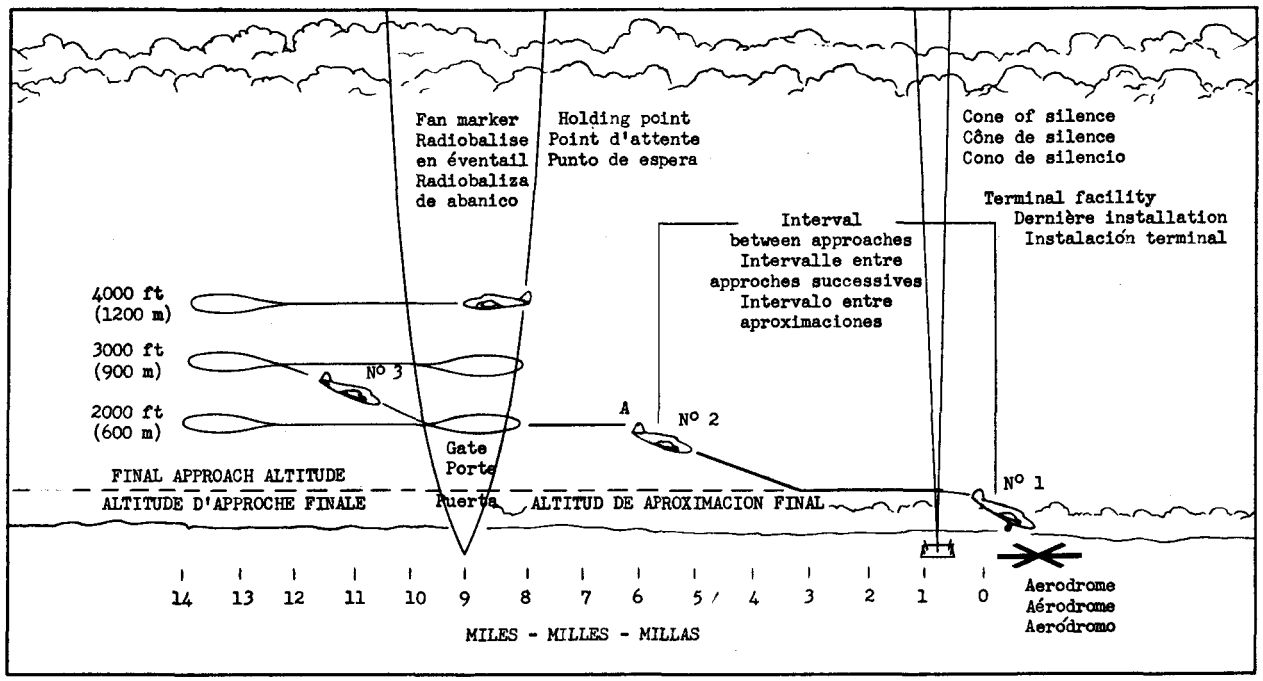
PROCEDURES D'APPROCHE
"APPROCHES MINUTEES"

Le schéma ci-dessus représente l'application des principes d'espacement dans le temps pour des approches successives. En respectant un intervalle de trois minutes entre approches successives, le contrôleur a autorisé les aéronefs nos 1, 2 et 3 à quitter la radiobalise pour effectuer leur approche à trois minutes d'intervalle. Lorsque les aéronefs ont quitté la position d'attente pour l'approche, l'espacement vertical est remplacé par l'espacement longitudinal.

PROCEDIMIENTOS DE APROXIMACION
"APROXIMACIONES SINCRONIZADAS"

Este dibujo esquemático ilustra la aplicación de los principios de separación de tiempo a una separación ordenada (un orden de aproximación). El encargado del control, utilizando un intervalo de tres minutos entre aproximaciones sucesivas ha autorizado a las aeronaves Núms. 1, 2 y 3 para que entren desde la baliza de abanico realizando aproximaciones con intervalos de tres minutos. Una vez que la aeronave perteneciente a un orden de aproximación entra en el campo a partir del punto de espera no se especifica ninguna separación vertical, utilizándose la separación longitudinal.

FIGURE 3 - FIGURA 3



APPROACH CONTROL PROCEDURES
VERTICAL SEPARATION

The above diagram shows an aircraft holding at 4000 feet; No. 3 leaving 3000 feet as instructed when No. 2 reported leaving 2000 feet; No. 2 has left fan marker at designated time maintaining 2000 feet until approach clearance received (Point A) where descent was started; No. 1 has been sighted, enabling the approach control office to clear No. 2.

PROCEDURES DU CONTROLE D'APPROCHE
ESPACEMENT VERTICAL

Le schéma ci-dessus représente un aéronef en attente à 1200 mètres (4000 pieds): l'aéronef nº 3 quitte le niveau de 900 mètres (3000 pieds), selon les instructions qu'il reçoit au moment où l'aéronef nº 2 signale qu'il quitte le niveau de 600 mètres (2000 pieds). L'aéronef nº 2 a quitté la radiobalise en éventail à l'heure spécifiée et est resté au niveau de 600 mètres (2000 pieds) jusqu'à ce qu'il ait reçu l'autorisation d'approche (point A); c'est alors qu'il a annoncé sa descente. L'aéronef nº 1 est en vue, ce qui a permis au bureau du contrôle d'approche d'autoriser l'approche de l'aéronef nº 2.

PROCEDIMIENTOS DE CONTROL DE APROXIMACION
SEPARACION VERTICAL

Este dibujo esquemático muestra una aeronave esperando a 4000 pies; la Núm. 3, según instrucciones, abandona 3000 pies cuando la Núm. 2 comunica que sale de 2000 pies; la Núm. 2 ha dejado la baliza de abanico a la hora designada manteniéndose a 2000 pies hasta recibir la autorización de aproximación (Punto A) donde comienza el descenso; ha sido vista la Núm. 1 lo cual permite a la oficina del control de aproximación autorizar a la Núm. 2.

PART II

UTILIZATION OF RADAR IN SPACING OF AIRCRAFT ON FINAL APPROACH

1. The objective in reducing intervals between successive approaches and landings can be achieved only by increasing the landing rate. The methods of achieving this end have been the subject of much study in many parts of the world, and the results of such studies should be collected, interchanged and studied further.

2. It is a characteristic of the type of the normal Instrument Approach Procedures that aircraft position themselves over a locator before commencing an approach, thus being required to perform manoeuvres during the performance of which ATC has no definite information on the position of the aircraft. This means that the time of the Controller is wasted. The use of such procedures severely limits the capacity of an airport as it invariably means, for safety considerations, that clearance to approach can be granted to but one aircraft at a time.

3. Such procedures are unsuited to airports which have a high traffic density requiring a rapid landing rate and it follows that the time wasting orientation manoeuvres must be dispensed with and replaced by more expedient procedures.

4. In order to achieve rapid landing it is necessary to feed aircraft, suitably spaced, onto what is defined in 3rd OPS Final Report (Part V) as "Final Approach", i.e., that part of an instrument approach procedure made in line with the axis of the runway in use when approaching to land or from the interception of a designated track to a point in the vicinity of the aerodrome from which a landing may be made. The method used is dependent upon the facilities available on the ground and in the aircraft. Consideration

must be given, therefore, to acceptable separation standards in relation to the equipment in use. In this connection at large airports, where the runway layout permits, it may eventually be necessary for simultaneous landings to be made on parallel or adjacent runways, and the procedures adopted should be such as to accommodate this requirement.

5. The aim of the United Kingdom trials is to evolve a system for immediate adoption using existing equipment as at present deployed. Radio Range Stations are so sited in relation to runways that the use of radar for feeding aircraft on to the final approach is facilitated, and all approaching aircraft can be under radar surveillance from the holding pattern to the threshold of the runway and can be directed as necessary.

6. The route length from the holding pattern to the threshold of the runway must be sufficient to allow aircraft to reduce altitude at a normal rate of descent, such that aircraft intercept the ILS glide path at the correct altitude and at the correct distance, to permit the pilot to settle down for the final stage of descent.

7. Assuming the vertical separation between aircraft "Holding" on a facility to be 1000', and the vertical descent speed of aircraft descending to occupy lower altitudes with other aircraft either carrying out the same manoeuvre below or holding beneath them, to be not more than 500' per minute it follows that the maximum allowable rate of clearing aircraft to the bottom of the holding stack is one every two minutes for single runway operation. Hence, the maximum theoretical landing rate from one holding stack is two minutes. This pre-supposes that aircraft are heading in the right direction when released to land and that ATC, communication and pilot actions are instantaneous.

8. The manoeuvrability of aircraft, speed of communication and ATC and pilot reaction are also limiting factors in a precise and rapid landing system and, as long as vertical stacking is a necessary preliminary to landing, a significant advance beyond a landing frequency of approximately one every three minutes is not possible from a single holding stack.

9. In view of the fact that it is undesirable and often impossible to vary the approach speed of aircraft the only way in which time/position errors and airspeed differences can be compensated is by varying the

route length flown between the holding pattern and the runway. If the time, position and airspeed of the following aircraft, and the position, time, route and speed of the aircraft preceding it are known, a route distance can be computed which, if flown by the following aircraft, will ensure that the interval of time between the two aircraft crossing the aerodrome boundary is in accordance with the time separation desired. This, of course, assumes knowledge of the wind velocity and accurate flying. However, progress has been made in this respect by local agreement with operators on three standard approach speeds namely,

Category I - 120 knots
Category II - 140 knots
Category III - 160 knots

10. The route length must vary in accordance with the actual time to be consumed in relation to the desired time interval and the airspeed of the following aircraft. As it is impracticable to construct or fly a curved track at present, route length variation is best accomplished by discrete-track routing.

11. The length of a discrete-track route is defined by the following considerations:

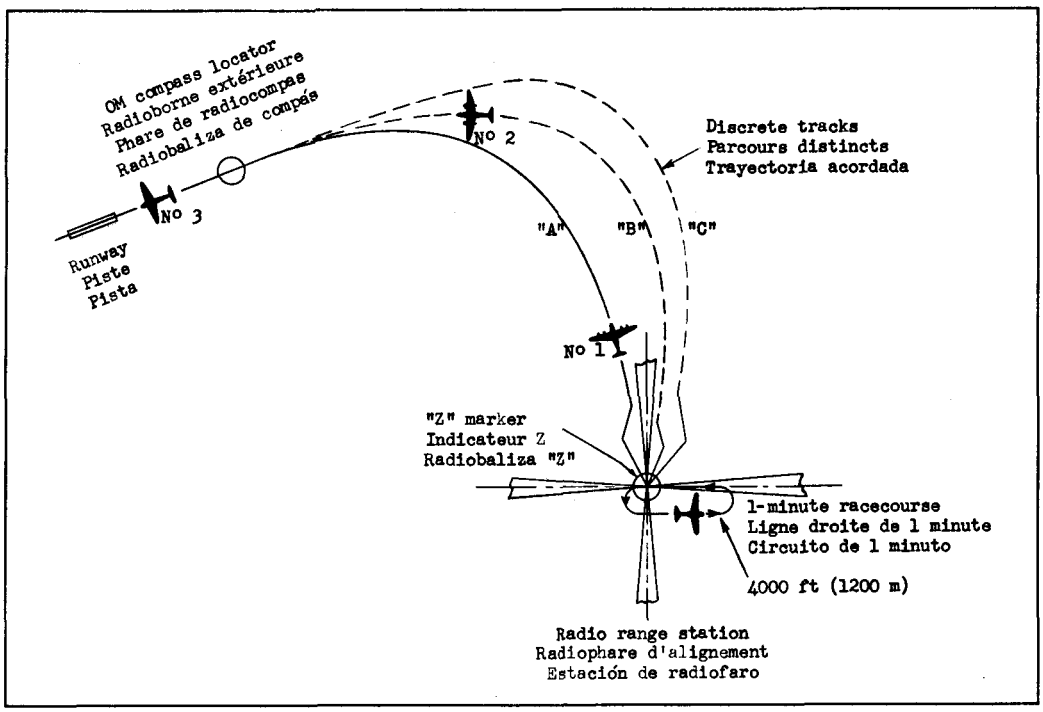
11.1 Aircraft must be able to leave the holding pattern via a prescribed exit point, e.g., a Radio Range Station - within reasonable tolerances of the prescribed leaving time.

11.1.1 The second aircraft of a sequence cannot be cleared down to the lowest stack altitude until the preceding one has left the exit point because this fact is only known when the pilot reports leaving the exit point or is seen to do so by radar.

11.1.2 Air Traffic Control cannot know the precise positions of aircraft on the holding pattern because it takes approximately 25 seconds of time to issue descent and time to leave instructions, when the preceding aircraft is known to be clear of the exit point.

11.1.3 It is apparent that the maximum warning the aircraft will receive of the time it is required to leave the exit point will be approximately 2-1/2 minutes.

FIGURE 4 - FIGURA 4



RAPID LANDING
DISCRETE-TRACK PROCEDURE

The above diagram shows an aircraft holding at 4000 feet. Aircraft No. 1 has just completed its distinctive track on discrete track "A". Aircraft No. 2 is approaching the extended centre line of the runway on discrete track "B". Aircraft No. 3 is approaching the threshold for landing from discrete track "C". It will be noted that the radio range station legs are aligned to provide additional track guidance in the preliminary part of this procedure for both directions of landing on the runway in use.

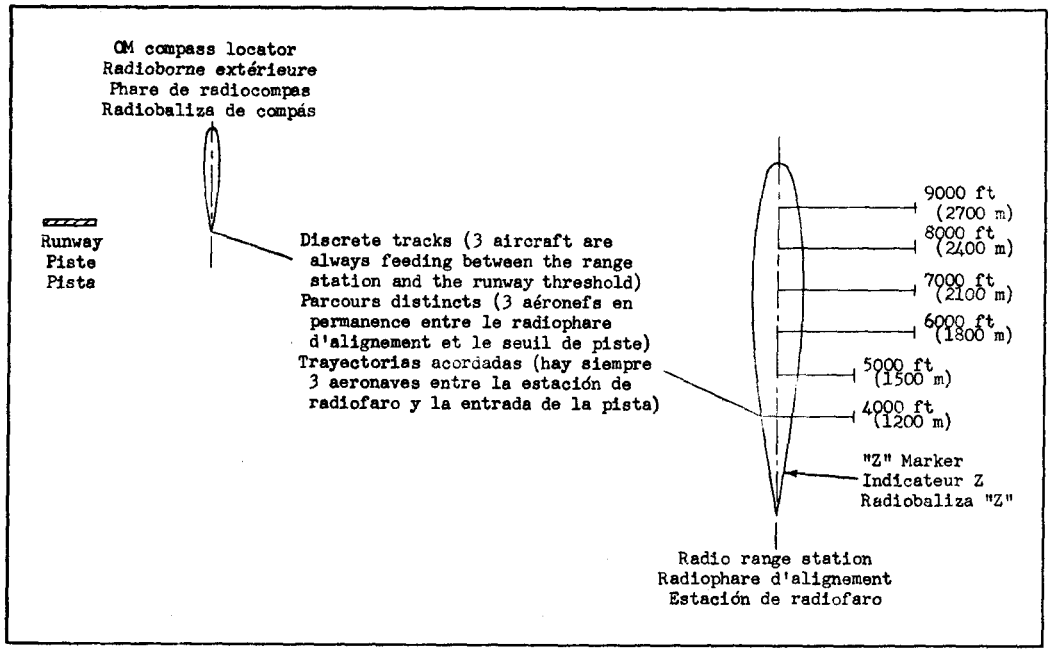
PROCEDURE D'ATTERRISSAGE A CADENCE RAPIDE
UTILISANT DES PARCOURS DISTINCTS

Le schéma ci-dessus montre un aéronef en attente à 1200 mètres (4000 pieds). L'aéronef n° 1 vient de terminer sa trajectoire arbitraire et se trouve sur le parcours A. L'aéronef n° 2 approche du prolongement de l'axe de piste en suivant le parcours distinct B. L'aéronef n° 3 approche du seuil pour effectuer un atterrissage après avoir suivi le parcours C. On remarquera que les faisceaux du radiophare d'alignement sont orientés de manière à fournir une indication supplémentaire de direction au début de cette procédure sur les directions d'atterrissage pour la piste en service.

PROCEDIMIENTO DE TRAYECTORIA
ACORDADA PARA ATERRIZAJE RAPIDO

En este dibujo puede verse una aeronave esperando a 4000 pies. La aeronave Núm. 1 acaba de completar su recorrido característico sobre la trayectoria acordada "A". La aeronave Núm. 2 se está aproximando a la prolongación del eje de la pista sobre la trayectoria acordada "B". La aeronave Núm. 3 se aproxima a la entrada de pista para aterrizar, desde la trayectoria acordada "C". Se notará que los haces de la estación de radiofaro están alineados para proporcionar guías adicionales en la parte preliminar de este recorrido para ambas direcciones de aterrizaje sobre la pista en servicio.

FIGURE 5 - FIGURA 5



RAPID LANDING
DISCRETE-TRACK PROCEDURE

The above diagram in elevation form shows the holding stack consisting of 6 flight levels: the two bottom levels in a 1-minute racecourse pattern, the 4 upper levels in a 2-minute racecourse pattern.

This diagram should be examined in conjunction with Figure 4 to obtain a complete appreciation of the system.

PROCEDURE D'ATTERRISSAGE A CADENCE RAPIDE
UTILISANT DES PARCOURS DISTINCTS

Le schéma ci-dessus indique en élévation la pile d'attente comprenant 6 niveaux de vol: les deux niveaux inférieurs correspondent à un circuit avec ligne droite de 1 minute, les 4 niveaux supérieurs à un circuit avec ligne droite de 2 minutes.

Il convient d'étudier ce schéma en même temps que la figure 4 afin d'obtenir une indication précise du système.

PROCEDIMIENTO DE TRAYECTORIA
ACORDADA PARA ATERRIZAJE RAPIDO

Este alzado pone de manifiesto el escalonamiento (pila) de espera que está formado por 6 niveles de vuelo: los dos niveles inferiores con circuitos reglamentarios de 1 minuto , los cuatro niveles superiores con circuitos reglamentarios de 2 minutos.

Este dibujo hay que examinarlo juntamente con el de la Figura 4 para apreciar debidamente el sistema.

11.2 Therefore, the holding pattern at the lowest altitude must be of such a shape and total length that from any point on it aircraft must not be more than 2 minutes flying time from the exit point and, the time to be consumed in the holding patterns above the lower one is related to the time requirement of the lowest.

12. The shortest approach distance, ignoring cross-wind effect, is a function of manoeuvrability of the aircraft, altitude at point of turn onto the final approach path, the distance of the holding pattern from the runway and the angle between a line joining that point and a point of turn onto final approach. If the aircraft is the second, or later, of a sequence, the length of flight path is a secondary consideration and at the earliest time of landing the primary consideration. Therefore, the aim should be to land the first aircraft using the shortest flight path. If the next aircraft was of the same speed and left the holding pattern on time it would follow the same path; if it left ahead of the desired interval it would follow a longer one, but if it left late, however, it would not be able to make up the time lost because the preceding aircraft is already using the shortest route. It is obviously desirable that the aircraft should be disposed about the mean discrete-track to maintain a regular interval between landings, especially if departures are to be interspersed between landings. This can be arranged by the Controller without great penalty to either runway or aircraft utilization.

12.1 The downward flow of aircraft must be consistent throughout all altitudes in the patterns, compatible with the required rate of leaving; large unequal intervals at this stage would magnify compensating action later.

12.2 Time is required in which to deduce "Time of leaving error" and to calculate the discrete-track. Whilst this is happening the aircraft must of course be flying at its normal speed but its progress must not complicate the calculation at this stage. For this reason it is necessary to allow the aircraft to fly an arbitrary track for a specific distance and refer all compensatory calculations to that point. This arbitrary track, referred to herein as the "distinctive track", also serves to permit identification of the aircraft from the others flying in the holding pattern. This short distinctive track does not necessarily lengthen the flight path between the holding pattern and touch-down. Rate of descent (500 feet per minute) may be the limiting factor in deciding the distance an aircraft must fly.

13. The difference between actual and intended times of leaving the stack must be determined. This can be derived from the pilot's report on passing the Radio Range Station and by radar surveillance. To safeguard against error both are required.

14. Proposed Procedures (see Figures 4 and 5)

14.1 Aircraft are marshalled at a holding point marked by a Radio Range Installation and there carry out a standard six-minute loop holding pattern (two-minute standard "Racecourse"). The aircraft are separated by 1000 feet vertical intervals. The overall time of the pattern flown at the two lowest stack altitudes is reduced to four minutes (one-minute standard "Racecourse"). Aircraft do not hold at either altitude in the true sense of the term when the system is operative but pass through them and adjust their position so that they are able to leave the Radio Range Station at the time required. They could be termed Transit Groups during the period a flow of traffic obtains.

14.2 The first aircraft to approach reports when passing over the holding facility and maintains a distinctive track from it for an arbitrary distance. Thereafter a precomputed discrete track, the length of which will depend on the approach speed of the aircraft, and other conditions (e.g., runway occupation) is flown to intercept the final approach path.

14.3 The next aircraft in sequence is instructed to reduce altitude immediately and leave the holding point after an interval - equal to the desired landing interval - has elapsed from the time at which the first aircraft departed. The pilot is required to report passing over the holding facility and to follow the distinctive short track from that point. Depending on whether, in relation to the scheduled time for departure, the aircraft leaves the holding position early, on schedule or late, and whether its approach speed is slower, the same or faster than the preceding aircraft, it will be directed to follow an appropriate course to make good a precomputed discrete track from the end of the distinctive track flown from the holding facility.

14.4 The tracks flown from the holding position will be observed by radar and any adjustments seen to be necessary will be made by the Traffic Director(s).

14.5 The effects of wind velocity are calculated and taken into consideration in the course given to maintain the desired track.

15. It is believed that the aim may be achieved using one holding stack. Nevertheless, consideration is being given to the fact that more rapid landings can be achieved by utilizing two stacks rather than one. However the time is inopportune to produce standard techniques and it is necessary that very effort should be made towards the production of a good system using a Standard Aid or combination of aids which will be internationally applicable.

16. In setting up such a system the importance of other related factors such as runway layout, provision of proper facilities and the training of controllers and pilots, should be borne in mind.

- END -

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