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THE EFFECT OF TURBINE-POWERED CIVIL AIRCRAFT ON THE DESIGN, CONSTRUCTION AND EQUIPMENT OF LAND AERODROMES

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INTRODUCTION

Although it is too early to say which aerodromes in the world will need to be capable of accommodating turbo-jet or turbo-prop civil transport aircraft as a regular routine, the time is ripe for considering how the advent of such aircraft is likely to affect aerodrome design, construction and equipment. By attending carefully to such matters now, it may prove possible, on the one hand, to avoid costly mistakes when new aerodromes are being constructed or existing aerodromes improved and, on the other hand, to ensure that aerodromes are made ready in good time to accommodate turbo-prop and/or turbo-jet aircraft, as and when they are introduced into regular air transport operations.

Sufficient information has now been collected through military flying experience, supplemented by a limited amount of development flying by civil turbine-engined transport prototypes, to permit listing a number of turbine-engined aircraft performance, structural, engine and operational characteristics that may need to be taken into account in aerodrome design and equipment. Part I of this circular presents these characteristics and indicates in connection with each the general elements of aerodrome design and equipment likely to be affected.

More difficult is to determine what direct or indirect effect each factor is going to have on aerodrome characteristics and equipment, and having done so, to determine what action, if any, should be taken. To assist those seeking a solution of this latter problem, and also to stimulate thought on the subject, a commentary based on selected elements of aerodrome design, construction and equipment is presented in Part II of this circular. The possible effects of future changes in air traffic control technique upon aerodrome design are not covered because solutions to control problems introduced by turbine-engined aircraft have not yet been fully developed.

In preparing the contents of Part I, the Secretariat has drawn upon statements by experts in this specialized field, made at the IATA Turbine-engined Aircraft Symposium (18 and 19 May 1950 - Asbury Park, New Jersey, U.S.A.) and, upon views presented in lectures, articles, etc. that have appeared in full or have been reported upon from time to time in the aeronautical and engineering press. It is not claimed that information thus collected and assembled is complete; nor are all the data guaranteed accurate at the time of printing: the fact that fresh evidence and data are being accumulated daily precludes completeness or accuracy. Those who are able to contribute additional information or suggestions are invited to communicate their views to ICAO Headquarters.

THE EFFECT OF TURBINE-POWERED CIVIL AIRCRAFT ON THE DESIGN, CONSTRUCTION AND EQUIPMENT OF LAND AERODROMES

PART I.- PERTINENT FACTORS

1.- AIRCRAFT PERFORMANCES

1.1.- Take-off distance and methods of accelerating take-off

Some manufacturers believe that requirements for main runway basic length in the case of turbine-engined airliners are dependent upon the landing distances, while others believe that the take-off distances are more likely to remain the limiting factor. Normally, in the operation of modern conventional civil transport aircraft, the accelerate-stop distance is the determining factor of the runway length; exceptions occur where the available take-off power of aircraft is appreciably higher than the minimum take-off power required by regulations.

Since turbine-engined airliners have to fly at greater altitudes than present day piston-engined airliners to achieve economic operation, their climb performances must allow for adequate margins at such high altitudes. The power and wing loading required for these climb performances appear at present to be such that, at sea level, under standard atmospheric conditions, turbine-engined aircraft automatically will have take-off characteristics that, in respect of required maximum runway length, are not much different from those of piston-engined aircraft.

There is no reason to believe that longitudinal runway slopes or wind speed will have any more effect on the take-off of turbine-powered aircraft than they do on that of comparable reciprocating-engined aircraft. There is evidence, however, that the effect of air density will be considerably greater on the take-off distance of turbo-jet and turbo-prop aircraft than on those with reciprocating engines. Such probable developments as increased engine operating temperatures will tend to make turbine-engined aircraft even more sensitive to low air density brought about by high atmospheric temperature and high aerodrome elevation. It has been forecast that the application of full "temperature accountability" when calculating the take-off distance of a 50,000 - 75,000 kg. (100,000 - 150,000 lbs.) turbo-jet airliner would, under adverse conditions, result in an increase of as much as 50% in the required runway length, as compared with that for take-off under standard sea level atmospheric conditions; this tendency can, however, be offset to some extent by the use of water/methanol injections. It would not be surprising to see rocket engines or solid fuel rockets fitted to jet airliners, to offset the increase in take-off distance that would occur at aerodromes where air density is low.

Note.- Aerodrome characteristics and equipment affected: Runway length, surface and construction.

1.2.- Landing distance and methods for decelerating aircraft after landing

If, as some manufacturers predict, wing loadings of turbine-engined aircraft do not exceed those of equivalent present day reciprocating-engined aircraft, the landing requirements of turbo-prop aircraft should be comparable to those of existing reciprocating-engined aircraft.

Unless the wing loadings of turbo-jet aircraft are lower than those of equivalent reciprocating-engined aircraft (a trend that some manufacturers consider probable in view of higher climb and altitude requirements of the former) landing distances are likely to be greater since there are no propellers to reverse and since reversible jets - or the equivalent - are not expected for some time to come. It may therefore be necessary to seek other means of deceleration. Parachutes might possibly be fitted to the tails of some jet airliners, which might be released as a normal part of the landing operation, or might be used only to produce additional deceleration in case of emergency. Such braking parachutes have been successfully tested; they open fully in 3 seconds; they do not drag along the ground and therefore do not tear by contact with the runway surface; to repack them after use is a comparatively simple operation. Another possible future method of providing deceleration additional to that produced by wheel brakes is the fitting of solid fuel rockets or rocket motors that can be fired forward in the direction of the landing run. All these methods will reduce landing distances but it is not certain whether regulations on performance requirements will admit of their use in establishing specific aircraft performances.

Note.- Aerodrome characteristics and equipment affected: Runway lengths, surface and construction.

1.3.- Climb after take-off

As a general rule, the best rate of climb achieved by jet aircraft will be greater than the best rate of climb achieved by reciprocating-engined aircraft. It may consequently be assumed that specifications concerning clearing and marking of obstructions in the approaches, if acceptable for conventional aircraft, will also be suitable for turbo-engined aircraft.

Note.- Aerodrome characteristics and equipment affected: Approach surfaces.

2.- AIRCRAFT STRUCTURES

2.1.- Aircraft loading and unloading

Because turbo-jet and turbo-prop aircraft have to be operated at high altitudes for economy, their cabins and crew compartments have to be pressurized to a differential of as much as 6 grs. per mm^2 (9 lbs. per sq. in.); with differential values as high as this, the design of safe air-tight doors becomes complicated. Although the passenger, freight and mail loading and unloading doors provided on contemporary civil airliners usually open outwards, the future trend may be towards inward opening. Furthermore, the tendency to fit shorter undercarriages, thus reducing structural weight, will probably increase. A subsidiary result of this change will normally be a lowering of cabin entrance doors.

Note.- Aerodrome characteristics and equipment affected: Aircraft loading equipment and apron design.

3.- ENGINE CHARACTERISTICS

3.1.- Type of fuel used and liability of spillage

It is possible that kerosene will be preferred initially to gasoline as the fuel for turbo-prop and turbo-jet engines in civil transport aircraft.

Both fuel distributors and airline operators feel that kerosene is likely to prove more economical, as well as safer, than gasoline; at the present time, the former costs about 5¢ per U.S. gallon less than the latter at any given place in the world; furthermore, although kerosene is not a "safety fuel", it has at least one characteristic that renders it safer than gasoline, namely its lower rate of flame propagation.

It appears that the time when pressure refuelling from under-wing positions becomes common practice is likely to be advanced by the advent of turbo-engined airliners, because of the quantities of fuel that have to be delivered to the tanks, which are larger than those of comparable present day aircraft. Long range airliners of approximately 50,000 kgs (100,000 lbs.) gross weight will have fuel tankage for 25,000 or more litres (nearly 6,000 Imp. gals. or 7,000 U.S. gals.). Maximum refuelling rates for contemporary jet prototypes are of the order of 800 litres (200 gallons) per minute, but are liable to increase in future to a somewhat higher value.

It is understood that the provision of 20,000 litres (5,000 Imp. gallons) capacity refuelling tankers is envisaged at all aerodromes along routes over which aircraft having four turbo-jet engines will operate. At some such aerodromes, hydrants from which the refuelling tankers can draw fuel or from which aircraft can be fuelled direct, are to be laid in suitable positions on the apron (ramp).

Some fuel may be spilled when engines are being started, particularly when one turbine fails to start immediately. Opinion differs as to whether or not appreciable quantities are spilled when throttles are closed suddenly or when they are opened. This defect is expected to diminish in the future. Spillage of fuel has a detrimental effect on bituminous pavement, if continuous cycles of spillage and passage of aircraft occur; no effect has been ascertained on concrete pavements except on joint materials (research on asphalts, tar and bituminized latex compounds is in progress but no definite solution has been advocated).

Note.- Aerodrome characteristics and equipment affected: Apron design, surface and construction; taxiway and runway surfaces; refuelling and crash-fire/rescue equipment.

3.2.- Entry of foreign bodies into the air intakes of turbo-jet and turbo-prop engines

Neither water nor snow appears to do any harm when it enters the air intake of a turbo-jet or a turbo-prop engine. Debris such as small stones on the surface of the landing area and pieces of pavement that have become dislodged from the surface of a runway are, however, liable to cause considerable internal damage if sucked into the air intake, which has been known to happen.

Note.- Aerodrome characteristics and equipment affected: Apron, taxiway and runway surface construction and maintenance.

3.3.- Effect of jet blast on pavements and adjacent ground

This effect depends on the following factors: a) type of jet used; b) height of the jet above the pavement surface; c) pitch of jet; d) period of gas action on the pavement.

a) The influence of the type of jet used is conditioned by the diameter of the exhaust nozzle, and by the temperature of the hot gases at the exhaust nozzle. From the existing types of jets, it can be presumed that these two parameters will not vary very much in the near future. The diameter of the exhaust nozzle is about 40 centimetres (16") and the temperature at the exit, at full power, is about 700°C (1200°F). At reduced power, the temperature will be less; for example, 390°C (750°F) at 60% of the full power.

b) The height of the jet above the surface varies with types of aircraft. In the civil type of aircraft equipped with tricycle undercarriages, this height will not be less than 3 feet.

c) The pitch of the jet is quite steep in the case of fighter aircraft equipped with tail-wheel undercarriages, but, in civil aircraft equipped with tricycle undercarriages, the jet centre line will be approximately horizontal. The pitch is variable according to the load distribution of the aircraft, and it is of course less with a full power thrust than at reduced power. The consequence is that, during take-off, the action on the pavement is less than when the aircraft is motionless or taxying.

d) This last factor is dependent upon operational requirements.

Velocity and temperature distribution curves in the jet wake of a nozzle have been established. From these curves it can be ascertained that, in the case of large turbo-jet aircraft at full power, the hottest point at the pavement level is about 12 metres (40 feet) directly to the rear of the jet pipe. At this point on the ground, the temperature is approximately 140°C (250°F), and the gas velocity 80 metres (270 feet) per second. At a point on the surface 30 metres (100 feet) from the jet pipe, the temperature has decreased to about 55°C (100°F), and the velocity to 21 metres (70 feet) per second.

The temperatures observed are sufficiently high to develop some plasticity in bituminous pavement; in cases where the application of the hot blast of gas is prolonged, it has been observed that the surface of the bituminous pavement has a definite flow and it may be scoured by the passage of another aircraft. However, under normal operating conditions, it has been proved that damage to bituminous pavement is less if the seal coat is tight and in good condition. On concrete pavements, neither the heat nor the blast produced by the jet engine has any destructive effect if the concrete is of good quality. The gradient of temperature between the upper and lower surfaces of the concrete slab is of course greater than that caused by variations of atmospheric temperature, but the affected portion of the pavement is very small.

The problem may, however, assume more serious proportions if and when rockets or rocket engines are used to assist take-off or to decelerate aircraft that have landed, or even if jets of much higher power than those in use for any purpose today are installed in aircraft, in such a way that their axes are inclined at an angle to the horizontal that causes blast to be directed at a point on the ground close to the exit of the pipe.

As far as grass-covered surfaces are concerned, when jet engines are run-up for test purposes on or near them, the grass for about 30 metres (100 feet) behind the jet pipes is burned and scorched, but the ground itself is not pitted.

Note.- Aerodrome characteristics and equipment affected: Apron, taxiway and particularly runway surface and construction, and also surface of ground adjacent to aerodrome pavements.

3.4.- Engine starting

Persons should always keep at least 2 metres (7 feet) away from the intakes of turbo-jet engines that are being started up or are running. When turbo-prop engines are being started, the "drill" is the same as in the case of reciprocating engines.

Current turbo-jet and turbo-prop engines are started through initial rotation by electric starter motors with power for the starters provided by an external source. Any use of the internal batteries is normally restricted to supplying electrical current to the igniter plugs and "winding" the "starter timing" mechanism. However, the trend is to use external power to supply complete "standstill" electrical requirements. The peak current drawn in starting an engine of approximately 1500 kgs. (3,000 - 3,500 lbs.) thrust is of the nature of 600 - 900 amps. However, the duration is so short that fully charged internal batteries will be able to give a "start" the same as with present day transports. It is indicated that external auxiliary power units (APU's) will continue to be the normal means of starting as they are required in any event to take other stationary aircraft electrical loads.

There is a possibility that "gas starters" will, in future, tend to replace electric starters for the larger classes of turbine. The question of whether the jet engines of civil airliners ought to be started on the apron, or alternatively somewhere else on the aerodrome after the aircraft has been towed away from the apron, is a highly controversial one. If they are to be towed, the tow truck should carry a generator which would provide the start for one of the engines. The others could then be started from the power produced by the first engine in motion. However, it is a fact that the engines of existing prototype jet airliners are usually started on the apron, whence the aircraft moves away under its own power. It seems that no more than 2 minutes will be needed to start and fully check all four of a civil airliner's jets.

Note.- Aerodrome characteristics and equipment affected: Apron and taxiway design and starting equipment.

3.5.- Compressor whine and jet roar

Compressor whine, which is greatest in a 15° cone about the thrust line and ahead of the engine, is an annoying characteristic of turbo-jet engines. Its magnitude is less with turbo-prop than with turbo-jet engines; taking into account probable future developments in impellor design, the prospects seem to be that turbine whine generally will tend to become less rather than more annoying. It should be practicable, if and when necessary, to design detuning walls that would reduce compressor whine, but it seems doubtful if the construction of such walls could ever be justified, except possibly around the test-beds in which turbine engines are tested after overhaul.

The "roar" of turbo-jet - but not turbo-prop - engines which is greatest in a 45° cone about the thrust line and to the rear of the engine may be more troublesome than "whine". Forward of this 90° angle the noise level is usually very much less. Assuming that jet airliners are started up on the apron where they have been loaded - as opposed to being towed away - it may be desirable in certain cases to incorporate blast walls that deflect upwards the hot exhaust gases emitted when the power necessary to accelerate from a standstill to taxying speed is applied. In general, however, full power will not be applied on the apron so that "roar" may not be too troublesome without blast walls.

Note.- Aerodrome characteristics and equipment affected: Apron design.

4.- OPERATIONS

4.1.- Procedure followed when proceeding from apron to runway

Whether aircraft are towed away from the apron or taxied off under their own power, it may well become standard practice for cockpit checks to be done whilst taxying out to the take-off end of the runway in use. This check, which will include everything necessary prior to take-off except run-up and final check of the engines, will occupy something between 2 and 4 minutes. If aircraft about to depart are taxied out to the runway under their own power, their speed will probably be at least 50 klm (30 miles) an hour, wherever the characteristics of the taxiways permit such a speed. A four turbo-jet aircraft will normally consume something over 28 kgs. of fuel per klm (100 lbs. of fuel per mile) taxied at a speed of this order. Thus, the extent to which taxying under jet power is acceptable at any particular aerodrome will usually depend upon the actual distance to be traversed between the apron and the end of the take-off runway. Slow-running fuel systems for turbo-prop aircraft, which reduce consumption to approximately 10% of present values under normal power in ground running conditions, are expected to be available shortly for use when taxying slowly or waiting.

With the power output employed when taxying, it seems that neither the heat nor the blast from turbo-jet engines is likely to create a serious problem, except for short sections where the speed of aircraft is limited (sharp curves, runway crossings, etc.). Aircraft operators generally are against towing because of the added complication and the high cost of the necessary equipment. Vehicles specially designed for towing aircraft in the 50,000 - 75,000 kgs. (100,000 - 150,000 lbs.) bracket and equipped with starting and fire extinguishing gear might cost as much as $35,000 each. On the other hand, some airport operators are anxious to see aircraft towed away from the apron, and part of the way out towards the take-off end of the runway in use. The spillage of kerosene (or gasoline) whilst refuelling and starting up or stopping engines near the main terminal building is thereby prevented; furthermore, noise and other effects that are liable to cause discomfort to personnel or to damage property are obviated, as is the remote possibility of danger to life and limb from air intake suction or jet blast.

It has been suggested that it might be desirable to bank taxiways at locations where they enter runways, in order to permit aircraft to start their take-off run with appreciable forward motion. It is calculated that a rolling start of 40 klm.h (25 mph) shortens the take-off distance by about 65 metres (220 feet). It has also been suggested that taxiways should be banked at all curves to permit higher taxying speeds.

Note.- Aerodrome characteristics and equipment affected: Apron design and taxiway length, transverse slope, changes in direction.

4.2.- Procedure when clearance for take-off is received

Once a turbo-jet aircraft is cleared for take-off by air traffic control - which clearance will, it is hoped, be given to the aircraft when it is taxying out to the end of the runway, thereby avoiding any delay that would lead to undue fuel consumption - it proceeds on the runway and stops in a convenient position from which to commence its take-off. Against locked brakes, engines are then run up to full power and checked - a process that takes approximately 15 to 20 seconds in the case of 4 turbo-jets - after which the brakes are released, with engines running at full power, and the take-off commenced. It is emphasized that this is the first and only occasion, from the moment of starting up onwards, on which engine revolutions are increased to a maximum to give full power.

Note.- Aerodrome characteristics and equipment affected: Taxiway/runway design and surface.

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PART II.- COMMENTARY ON THE EFFECTS THAT THE FACTORS LISTED IN PART I ARE LIABLE TO HAVE ON LAND AERODROME CHARACTERISTICS AND EQUIPMENT

1.- RUNWAYS

1.1.- Basic length

Theoretical considerations appear in Part I. Another factor is that aircraft designers and operators are aware that their turbine-engined models will have to replace reciprocating-engined types on air routes that are already provided with aerodromes that cannot be enlarged without serious economic, and, in some cases, technical difficulty. In other words, they appreciate that the turbine-engined airliners of the future must be made to fit the existing airports that serve the air routes over which they will be operated. As a consequence, neither take-off nor landing distances are expected to differ markedly from the values applicable to the corresponding reciprocating-engined airliners in use at the present time.

1.2.- Approach surface slopes

For the same considerations as those indicated in 1.1, it can be expected that, generally, approach slopes less steep than those recommended by ICAO will not be required.

1.3.- Allowances for air density

At the present stage of development of turbine engines, low air density brought about by high altitude, high temperature, or a combination of the two, has a more adverse effect on power output than it does on reciprocating engines. This was anticipated by the ICAO Aerodromes, Air Routes and Ground Aids (AGA) Division, but as insufficient information was available on this question at the time of the meeting, the Division was forced to adopt a "rule of thumb" correction formula which was known to be reasonable for the average civil airliner then operating. It might therefore be prudent, particularly in the case of an aerodrome situated in the tropics, to use another correction formula that takes the temperature effect into account independently, as was suggested by the Division.

1.4.- Longitudinal slopes

On present information, it does not seem likely that any variation in the latest ICAO specifications concerning the maximum longitudinal slopes allowable along runways will prove necessary; nor will there be any appreciable change in the problem that faces ICAO of deciding upon a standard method of correcting basic runway length to offset the effects of longitudinal slopes on aircraft take-off and landing performance.

1.5.- Surface and construction

It has been demonstrated that débris on runways can be sucked into the air intakes of turbo-jet engines with consequential damage to the compressor. However, this hardly seems likely to be a serious consideration in the case of turbine-engined airliners in the 50,000 kgs. (100,000 lbs.) plus class, since their air intakes will be sufficiently high above the runway surface to render slight the possibility of débris entering them.

As said in Part I, it has been established that spilled kerosene sometimes causes the surface of a flexible pavement to become softened; where this happens, the hot gases that leave jet engines at high velocity during the aircraft's take-off tend to dislodge portions of the pavement. This, in turn, leads to the creation of a type of débris that can be sucked up into the engines. One obvious method of preventing this process of deterioration is to maintain all flexible runway surfaces in first-rate condition. It has been ascertained that dense graded asphaltic concrete offers good resistance under normal operating conditions. The use of tar in bituminous mixtures, and especially in seal coats, further improves this resistance.

Concrete does not seem to suffer from the effects of spilled kerosene or, if of good quality, of jet blast; regarding the joints, the use of rubber compounds as joint sealer is advocated as satisfactory; this may be due to the fact that kerosene never truly dissolves rubber, even though it may plasticize it. Those more experienced in jet aircraft operations now incline to the view that rigid pavements are essential, at least for the first 100 metres (300 feet) at each end of every runway.

The effect of rockets used for assisting in aircraft's take-off or decelerating its landing cannot yet be assessed, although the possibility of future developments in this direction tends to endorse the theory that, in future, concrete will prove more suitable for runways than flexible-type pavement. However, it is probable that concrete itself will not resist the test of heavy traffic of rocket-assisted operations, when the temperature of the runway surface exceeds 1000°C (1832°F). Special sealing and insulating coats have been experimented with; one is a plaster coat mixture of an equal proportion of cement and asbestos, of different thicknesses 6,3 - 12 and 19 mm (0,25", 0,5", 0,75"). This plaster coat is trowel-spread and reduces considerably the temperature on the pavement surface, but it does not resist tangential strains. It appears that it can only be used on limited surfaces, and specially on aprons. Another product, consisting of a mixture of lime and mica, can be sprayed with a cement-gun. Its insulation characteristics appear to be nearly perfect. Another device is to use fire-resisting cement, i.e., aluminium cement instead of Portland cement, or to build the appropriate part of the movement area with fire-resisting ceramic products.

1.6.- Surface of runway shoulders

It seems that closer consideration than in the past will need to be given to the provision of shoulders along the edges of runways. There is, for instance, the possibility that kerosene that has spilled and drained towards the runway edge will catch fire under the influence of jet or rocket blast or for other reasons, and that the fire will thereafter spread to dry grass along the edge or at the end of the paved runway.

1.7.- Aircraft waiting platforms

Mention has been made of the high rate at which fuel is consumed when turbine-engines airliners are taxying; the same applies when they are kept waiting prior to take-off. Reference will also be found to the possibility of turbine-engined airliners being given clearance to take off while in the process of taxying out from the apron to the end of the runway. It should be recognized that this latter practice may not always prove practicable. However, whichever procedure is adopted at a particular aerodrome, it is good practice to provide taxiways that branch into at least two adequately separated paths leading to the runway end to enable stationary aircraft to be bypassed.

2.- TAXIWAYS

2.1.- Length

If a turbine-engined airliner has to taxi two miles prior to take-off, the amount of fuel consumed may, in the case of a 100,000 lbs. aircraft, be equivalent to the loss of one fare-paying passenger in the case of a "full tank" operation, unless the fuel tanks are refilled at the take-off point. This is one of several reasons why the length of taxiways linking the apron to the ends of runways should be reduced to a minimum. In the case of aerodromes yet to be built, this can be achieved by a judicious positioning of the terminal building and its apron with respect to the runway pattern, and by ingenious runway layout arrangements. The problem, however, is usually more complicated in the case of an existing aerodrome.

2.2.- Other characteristics

To offset the effect of high fuel consumption when taxying, the natural tendency is to increase taxying speeds. This, in turn, suggests that abrupt changes in direction that necessitate slowing down a taxying aircraft should be avoided. Where sharp changes in direction cannot be avoided, the idea of banking taxiway curves may in certain cases prove worthy of consideration. The proposal that taxiways be banked where they join runways does not, however, appear to warrant serious consideration, because advantages to be gained are insufficient. Another way of promoting higher taxying speeds may be to increase the radius of fillets at taxiway intersections and also where taxiways join or cross runways. The longitudinal slope changes as well as the sight distance on taxiways, as now specified by the AGA Division recommendations, may also require some modification.

2.3.- Surface and construction

Much the same remarks as those appearing in Paragraph 1.5 above apply, except that the problem of resistance to rocket blast will not arise in the case of taxiways. Special attention should be paid to sections where the speed of taxying turbo-jet aircraft will be limited (sharp curves, runway crossings, etc.).

2.4.- Shoulders

The problem arising under this heading is similar to that dealt with under Paragraph 1.6 above, except that the chance of fuel spilling and igniting will probably be less in the case of taxiways than runways. The possibility of dry grass along the edges of taxiways being ignited by jet blast is probably greater than in the case of runway shoulders, particularly in cases where the taxiways are narrow and winding.

3.- APRONS

3.1.- Design, including size, shape and layout

The problems to be faced under this heading will depend on whether aircraft are: a) towed, or b) taxied under their own power up to and away from the apron. In the former case, the principal points to be borne in mind are the need for allowing sufficient space for manoeuvring aircraft in tow, and for providing satisfactory equipment for towing aircraft and then starting their engines when they have been moved to a position away from the apron. In the latter case, fuel spillage may prove somewhat of a problem, as may the protection of personnel, equipment and structures from the heat and noise of jet blast.

3.2.- Surface and construction

As in the case of Paragraph 2.3 above, what has been said in Paragraph 1.5 applies almost equally in the case of apron design and construction. Concrete pavement seems to be necessary at those parts of an apron where turbo-jet aircraft are being overhauled or started.

4.- EQUIPMENT

4.1.- Refuelling

Both turbo-jet and turbo-prop aircraft will carry more fuel than their present day counterparts. Fuel will usually be supplied to them under pressure from refuelling tankers via points beneath the wing. It will be necessary to consider whether tankers of sufficient capacity can be made available, or whether it will be necessary to install hydrants, for fuel distribution purposes, at appropriate points on the apron (ramp) from which tankers can themselves refuel, or from which aircraft can be refuelled direct.

4.2.- On and off loading of passengers, freight and mail

It should prove possible, in future, to simplify equipment used for loading and unloading aircraft, if outward-opening cabin doors disappear and if cabin entrances and baggage-loading hatches are located nearer the ground than they are on present day aircraft.

4.3.- Starting

For some time to come, a source of electric power mounted on a trolley or similar vehicle will normally be used to supply the energy necessary for engine starting in the same manner as presently used with piston engined aircraft. The precautions to be taken in the vicinity of aircraft whose engines are being started up seem unlikely to become more stringent than they are at the present time, except to the extent that extra care will have to be exercised to ensure that blast from turbo-jet engines does not cause injury to personnel or damage to property.

4.4.- Crash-fire and rescue

It is possible that the somewhat different combustion characteristics of kerosene, as compared with those of gasoline, will lead to modification of equipment and technique for rescue and fire-fighting in the event of a crash. There are indications that the occupants of airliners whose engines burn kerosene are less likely to be asphyxiated if fire results from an aircraft crash than would be the case if the fuel were gasoline. This suggests that, provided fire can be kept out of the cockpit and cabin, the problem of getting occupants out of a crashed aircraft may be less difficult in future than it has been in the past, because trapped persons will be better able to help themselves.

CONCLUSION

As traffic of turbine-engined aircraft will be relatively light in the immediate future, few of the changes listed in Part II are required at the present time. However, the development of operations of this new type of aircraft should be followed carefully; in particular, aerodrome authorities should study, in each specific case, the remedies and improvements required at each aerodrome concerned, taking into account the probable density of traffic of turbine-engines aeroplanes. These studies, if made in good time and with the exercise of sound judgment, will certainly further the progressive and economical development of adequate aerodromes.

- END -