

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) VEHICLE DECELERATING MEANS

- (71) We, BRITISH INDUSTRIAL PLASTICS LIMITED, a Company organised under the laws of Great Britain, of Asbestos House, 77—79 Fountain Street, Manchester 2, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—
- 10 This invention relates to means for decelerating aircraft and other vehicles.
- British Patent Specification No. 1,092,255 describes a method of arresting aircraft if they overrun the end or run off the side of a runway, and of retarding motor cars or other vehicles that run off a road or race track. The method described in that specification involves providing a bed of crushable rigid foamed material, such as an aerated concrete or plaster, extending across the end of, or along the side of, a vehicle track such as an aircraft runway or a road. The strength of the foamed material used must be such that the wheels of the vehicle running off the track and on to the bed will crush the foamed material, the effect of this being to exert a drag on the wheels, so slowing the vehicle down. Aerated concrete having a density between 15 and 60 lb. per cu.ft. and a compressive strength of 40 to 200 lb. per sq. in. is described as being suitable, although for retarding road vehicles concrete having a low density (e.g. 15 to 20 lb. per cu.ft.) and a low compressive strength (e.g. 40—50 lb. per sq. in.) may be adequate.
- We have now found that certain foamed plastics materials may be employed with advantage as the crushable foamed material used for example as described above to retard the travel of aircraft overrunning air-strips and of motor vehicles straying from the road.
- According to the present invention the foamed material is a non-resilient cured foam of aminoplast resin material and has a compressive strength as hereinafter defined between 1 and 50 p.s.i. and a density of from 0.25 to 10 pounds per cubic foot.
- "Compressive strength" is defined as the load in p.s.i. required to penetrate the material to a depth equal to 50% of its thickness. Thus, if the load required for 50% penetration is 10 p.s.i., the material has a compressive strength of 10 p.s.i.
- When we speak of a "non-resilient" material we mean a material which, after compression to 50% of its original thickness, does not recover to more than 75% of its original thickness. For example, if a material of thickness 4 inches is compressed to a thickness of 2 inches and the compressive load thereafter removed, and if the material then recovers to a thickness of 3½ inches, it is not suitable for present purposes. If, however, the material recovers to a final thickness of 2½ inches, it is suitable.
- One advantage of using a foamed aminoplast resin material (hereinafter called "foam" for convenience) for this purpose is that should any of the material, when shattered by the impact of the vehicle as it passes through the foam, be thrown into, say, an air intake of an engine, little damage, compared with the effect of a piece of concrete or plaster entering the engine, is likely to ensue.
- Furthermore, we have found that a foam having a relatively low density is adequate. Thus, foams having a density of from 0.25 to 10 lb. per cu.ft., usually of from 0.25 to 5 lb. per cu.ft. and preferably of from 0.25 to 3 lb. per cu.ft., are quite satisfactory.
- Surprisingly also, and in contrast to what is disclosed in Specification 1,092,255, we have found that even for the retardation of aircraft, a foam having quite a relatively low compressive strength is effective. Thus a compressive strength between 10 and 40 lb. per sq.in., preferably between 15 and 30 lb. per sq.in., and more preferably between 20 and 25 lb. per sq.in., is generally adequate. Of course, the speed and weight of the vehicle entering the foam, and the maximum

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- deceleration force which can be tolerated will influence the choice of material, but densities and compressive strength within the ranges above specified are usually satisfactory for most applications. In considering the choice of foam characteristics, the permissible length of foam bed, the effect of brakes on the vehicle itself, etc. will all be taken into consideration.
- It will be clear that the function of the foam is ideally to bring about the stopping of a vehicle in the shortest possible distance and at the same time subject the occupants of the vehicle to the least possible injury or shock. It has been calculated that the maximum retardation force which can be withstood by both an aircraft and its passengers without serious damage to either is about 1g, so that a foam which will give, in the particular circumstances, a retardation or deceleration force of 0.7–0.9 g is extremely suitable. Foams having compressive strengths in the range 15 to 25 p.s.i. are suitable for this purpose. Weaker foams, e.g. having compressive strengths in the range 1 to 10 p.s.i. are suitable for retarding lighter vehicles such as motor cars. It will be appreciated that when we speak here of "lighter" vehicles we mean vehicles which exert less pressure on the foam; it is the loading on unit area of the vehicle in contact with the foam which is the important feature.
- Other physical characteristics of the foam employed are also important. Thus, we have already described the foam in terms of its non-resilient and compressive strength. The foam should also be capable of substantially retaining its integrity (i.e. its size, shape, density and compressive strength) during a usefully long period of time, and should be able to withstand weathering and bacteria. It must, however, be capable of collapsing under pressures likely to be imposed upon it by a vehicle of the size and wheel loading which it is desired to arrest. When crushing does occur it is desirable that actual breaking of the foam occurs, not that it is simply compressed, since mere compression of the foam, if it is followed by an elastic expansion, could cause the vehicle, particularly a fast travelling aircraft, to bounce dangerously.
- Examples of aminoplast resins which may be used to give a foamed product which can be used in accordance with the invention are urea-formaldehyde (U.F.) and melamine-formaldehyde (M.F.) Mixtures of these may be used, for example UF/MF resins, as may modified resins, for instance those modified by reaction with a polyhydric compound such as glycol.
- Preferably, for obvious reasons, the foam is non-inflammable, and therefore the aminoplast resins, especially urea-formaldehyde, are particularly suitable. A flame retardant additive may also be incorporated, for example cyclic organic sulphites, lead sulphite and zinc sulphite, chlorine-containing compounds, e.g. polyvinyl chloride, phosphorus compounds and alumina.
- It should be noted that the foam densities given above relate to the foam alone, excluding any included material, but it will be appreciated that it is possible to produce foams comprising a proportion of material contained in the cavities of the foam, and the presence of such included materials, as other gases, for example carbon dioxide, Freons ("Freon" is a Registered Trade Mark) and bromochlorodifluoromethane (BCF), and liquids, for example water and oil, is not excluded. Such inclusions may be beneficial in that suitable flame-extinguishing agents may be incorporated which, on being released, blanket any fires which may already have broken out, or may effectively prevent subsequent ignition of, say, spilled fuel. BCF is such an additive, and, having a boiling point of -4°C , is suitably used as the blowing agent in the preparation of the foam.
- It is also possible to improve the weather resistance of the foam by the use of suitably compatible coating materials. For example, urea-formaldehyde foam may not itself have sufficient weather and bacteria resistance for the purposes of the invention, but its useful life can be extended considerably by coating surfaces exposed to weathering and bacteria with a suitable paint. Satisfactory paints for this purpose include chlorinated rubber based paints, urethane lacquers, unsaturated polyesters, latex and solvent based air drying paints, bitumen pitch, heavy oils and chlorinated waxes. Such a coating, even though it may not be necessary for the weather protection of all foams, may still be advantageous in that it could be brightly coloured to give warning of the whereabouts of the foam bed. Of course, if the paint is an inflammable one, and many are, the foam should include self-extinguishing additives, as mentioned above.
- The precise technique used to form the foam will depend to some extent upon the aminoplast resin selected, and no problem will be presented to the skilled man in this respect. The foam is preferably one which can be made *in situ*, the normal method for making urea-formaldehyde foam being by mechanically beating air into it. Alternatively the foam may be made in blocks in the factory and subsequently transported to the site.
- Deterioration of the foam may also occur by contact with soil or ground water, and if the material used is likely to be exposed to conditions conducive to such deterioration, then suitable steps, for example the provi-

sion of drainage channels and ditches, will normally be taken. Again, the surface of the foam may be contoured so that water falling on it will drain in a desired direction; for example, on an aircraft runway a high point along the centre of the runway, sloping gradually towards the sides, will usually be preferable. Protection of the foam from soil and ground water, if this should be necessary, can be by laying it on a concrete base, perhaps continuous with the runway, and bounding the foam bed along at least one of the sides with, say, a polyester/glass fibre sheet.

To reduce the likelihood of a vehicle knocking the foam out of its path on impact, or of strong winds blowing the foam away, and this is a distinct possibility when the foam bed is made up of relatively small blocks of foam, the foam bed is preferably secured to the ground. This may be effected by gluing or by the use of pins. Sometimes it may be desired to excavate a piece of ground of the appropriate dimensions and to the desired depth, and to fill the hole so obtained with the foam.

In certain circumstances it is desirable for the thickness of the foam to increase gradually in the direction of travel. This is especially so when the foam is below ground level, since otherwise there is a possibility that the vehicle will overturn. Also, with such increasing thickness, a light or slow moving vehicle may be arrested on the shallower part, the thicker section serving to retard heavier and faster machines.

The decelerative effect may also be increased with depth of penetration into the foam bed by employing foams of different densities and compressive strengths at different parts of the bed. For example, a low density, low compressive strength foam could be used at the entry to the bed (e.g. at the end of the normal runway), sufficient perhaps to arrest light vehicles, while further along the bed, a more dense, stronger foam could be used which would more effectively slow down larger, heavier or faster travelling vehicles.

The invention is not, as has already been intimated, restricted to the retardation of aircraft. Beds of foam can be employed in conjunction with roads and race tracks, to arrest vehicles departing from the selected path. In particular the application of the invention to motorways and dual-carriageway roads in general is envisaged. One of the problems facing the designers and builders of such roads is the tendency for vehicles, when they get out of control, to cross the central strip of the road separating carriageways, and to enter the carriageway carrying traffic travelling in the opposite direction. The use of beds in the central reservation is useful in helping to bring about

deceleration of the aberrant vehicle. Particularly, we feel, foam beds can be used in conjunction with a fence down the centre of the central reservation. The use of a central fence, of material strong enough to prevent passage of a vehicle to the opposing carriageway, is often objected to on the ground that a vehicle hitting it can be thrown back onto its own carriageway at only slightly reduced speed. The provision of a bed of the foam at each side of such a fence, however, would help to prevent such deflection, since the wheels of the vehicle would be trapped in the foam and would tend to hold the vehicle against the central fence.

The depth of foam, and its strength, would be determined by experiments to find the most appropriate combination.

In the accompanying drawings, Figures 1 to 5, 7 and 8 are diagrammatic sectional elevations of an airfield runway showing the use of different configurations of foam bed. Figure 6 is a diagram of part of a motorway showing the central reservation and parts of the carriageways on either side thereof.

Referring to Figure 1 a bed of foam 10 is secured to the ground at the end of a runway 12. The arrow shows the direction of approach of the aircraft. In Figure 2 the foam bed is composed of a number of blocks of foam, 14, 16, 18 etc., of varying densities and compressive strengths.

In Figure 3 the bed 10 is shown as increasing gradually in thickness for the first few yards and then levelling off.

The foam bed 10 shown in Figures 4 and 5 (Figure 5 is a section on the line V—V of Figure 4) is of uniform cross-section and has a central portion 11 and sloping sides 13. A bed of this structure has a centralising effect on aircraft using it, the aircraft being retarded more by the thicker central portion, and the sloping sides allow recovery vehicles to run on to the foam bed. Of course, the foam should be strong enough to carry such recovery vehicles.

With reference to Figure 6 numeral 20 represents, say, a northbound carriageway and numeral 22 a southbound carriageway of a motorway. Between the carriageways 20 and 22 is a central reservation made up of hard shoulder portions 24 and 26 and a central fence 28. A block of foam 30 according to the invention is situated on either side of the fence.

Figure 7 shows a set-up similar to that of Figure 1. In this case, however, a piece of ground has been excavated to accommodate the foam 10, the upper surface of which therefore represents a continuation of the runway 12. In Figure 8, the foam bed is composed of a number of blocks of foam,

14, 16, 18, etc., of varying densities and compressive strengths.

- In an experiment conducted to demonstrate the utility of the invention, "true scale" Lightning and Canberra aircraft (i.e. models in which the wheel dimensions and loading, tyre area, weight distribution and entry speed were all in the correct proportion on the scale 1:9.3) were fired into a bed of foam at a simulated 75 knots. The foam was a cured foam of urea-formaldehyde resin 3 inches thick by 3 feet wide by 45 feet long, having a density, after drying for 1 hour at 120°C, of 9 ozs/cub.ft. and a compressive strength of 2 p.s.i., this thickness and compressive strength having been selected on the same scale as the model aircraft. The density is that which gave the required compressive strength.
- Both aircraft stopped within 42 feet, which represented a retardation force attributable to the foam of 0.9g.

WHAT WE CLAIM IS:—

1. A bed of crushable foamed material extending across the end of or along the side of a vehicle track, wherein the foamed material is a non-resilient cured foam of an aminoplast resin material and has a compressive strength as hereinbefore defined between 1 and 50 p.s.i. and a density of from 0.25 to 10 pounds per cubic foot.
2. A bed as claimed in claim 1 wherein the foam has a compressive strength between 1 and 40 p.s.i.
3. A bed as claimed in claim 2 wherein the foam has a compressive strength between 15 and 30 p.s.i.
4. A bed as claimed in any of claims 1 to 3 wherein the foam has a density of from 0.25 to 5 pounds per cubic foot.
5. A bed as claimed in claim 4 wherein the foam has a density of from 0.25 to 3 pounds per cubic foot.
6. A bed as claimed in any of claims 1—5 wherein the aminoplast resin is a urea-formaldehyde resin or a melamine-formaldehyde resin.

7. A bed as claimed in any of claims 1 to 6 wherein a flame retardant additive is incorporated in the resin.

8. A bed as claimed in claim 7 wherein the flame retardant additive is a cyclic organic sulphite, lead sulphite, zinc sulphite, a chlorine-containing compound, a phosphorus compound or alumina.

9. A bed as claimed in any of claims 1 to 8 wherein a flame-extinguishing agent is incorporated in the resin.

10. A bed as claimed in claim 9 wherein the flame-extinguishing agent is bromochlorodifluoromethane.

11. A bed as claimed in any of claims 1 to 10 wherein the surface or surfaces exposed to weathering and/or the action of bacteria are provided with a protective covering.

12. A bed as claimed in claim 11 wherein the protective covering is a coating of paint.

13. A bed as claimed in claim 10 wherein the bed is bounded along at least one side by a sheet of glass reinforced polyester resin.

14. A bed as claimed in any of claims 1 to 13, the bed being secured to the vehicle track.

15. A bed as claimed in any of claims 1 to 14, wherein the thickness of the bed increases in the direction in which it is desired to retard the vehicle.

16. A bed as claimed in any of claims 1 to 15 comprising foams of different densities and different compressive strengths at different parts thereof.

17. A bed of crushable foamed material extending across the end of or along the side of a vehicle track, substantially as hereinbefore described with reference to and as illustrated by the drawings.

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Agent for the Applicants.

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