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FLEXIBLE BLANKET

The present invention relates to flexible blankets, and more particularly to such blankets for protection or stabilisation of underwater structures and pipe lines, sea and river beds, embankments and other situations subject to instability and erosion.

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It is common practice to lay pipe lines on the sea bed between for example oil production platforms and onshore processing facilities. However, as a result of strong currents the sea bed is a very unstable environment. Scouring can remove the sea bed from beneath any object which interrupts the flow of the currents and sand waves can erode the entire sea bed over a considerable area. Furthermore the temperature and viscosity of the product conveyed may induce regular movement and oscillation of the pipe line. Many methods of pipe line stabilisation have been employed with varying degrees of limited success.

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Damage from trawl boards, anchors, debris and the like is another problem facing pipe lines. Further, anchor chains or construction lines may cut through protective concrete coatings and damage exposed pipes. A stabilisation system therefore which can additionally provide significant mechanical resistance has particular advantages.

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5 It is known to provide pipe lines with a pre-cast reinforced concrete coating. This provides ballast and mechanical protection but renders the pipes more difficult to install and necessitates more sophisticated installation vessels as required coating thicknesses increase. In order to obtain sufficient ballast, the thickness of concrete may need to be quite considerable and in order to remain within practicable limits, supplementary ballast may still be needed. Such coatings do not address the problems of sea bed scour since their external contour, like that of a pipe, maximises turbulence and thereby underscour of the pipe line foundation.

10 It is also known to entrench pipe lines but this again does not overcome the problem of sand wave erosion which may cause the sea bed elevation to reduce by more than the limit of trenching depth capability.

20 Another method used in an attempt to overcome the problem of erosion is rock dumping. However, to prevent scavenging of sediment through the rock, a filter bed of graded particles needs to be built up as a preliminary. The particles of rock are not bound one to another and hence movement and sifting occurs in hydrodynamic surge. Erosion at the perimeters is progressive and unavoidable. Positioning of the rock is difficult to control and the potential of damage from the drop is considerable.

25 Another method tried is the provision of concrete saddles. However, this method, in common with other methods using rigid protection, is only successful when the unit is laid on stable foundations. Such methods are completely unable to withstand or prevent erosion of foundations by sea bed scour.

30 A more flexible version of the concrete saddle is the provision of concrete grout bags. These are only flexible at a limited number of hinge points and are expensive to install.



Another known method is the provision of filled bitumen mattresses. These are in theory flexible but the theory is severely limited by the disadvantageous properties of the bitumen. In warm weather, bitumen is comparatively fluid and the mattresses must be subject to considerable constraint in handling, transportation, storage and installation. However, in cold weather, bitumen becomes so hard that the mattresses are rigid and brittle. Temperatures at the sea bed are low and thus once installed, the mattresses lose their ductility and flex only very slowly. This slow flexing may be sufficient to accommodate gradual changes in the sea bed caused by erosion but is not sufficient to accommodate the degree of flexing caused if it is desired to move the mattress after installation to a new location on the pipe line or if the mattress is disturbed by anchors, trawl boards etc. Furthermore, bitumen becomes gradually more brittle with age and thus mattresses using bitumen have a limited period of practical benefit.

It is an object of the present invention to provide a flexible blanket which, in addition to its general superiority, overcomes the above disadvantages.

According to a first aspect of the present invention, there is provided a flexible blanket for protection or stabilisation of underwater structures and pipe lines, unstable beds and embankments, the blanket comprising a plurality of segments arranged in one or more layers each one segment in height, the segments of the or each layer being disposed substantially contiguously at least at a median zone of their height dimension, each segment tapering substantially regularly from a maximum cross section at said median zone to a minimum cross section at one or both ends thereof and each segment being so bonded to each adjacent segment in the region of their respective median zones that the segments are held substantially contiguously but are free to pivot relative one to

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another about the bond in so far as is permitted by said taper, the arrangement of the tapers being such that each segment is capable of pivoting with more than one degree of freedom.

5 Thus the blanket is very flexible and can be used to mould about almost any required contour.

10 Preferably each segment is, in plan view, a regular polygon. Advantageously each segment is, in plan view, a regular hexagon. The blanket produced with such segments is extremely flexible.

15 The segments may taper from the median zone to one end only, the other end being parallel-sided; or alternatively they may taper from the median zone toward each end. If the segments are only tapered to one end, the resulting blanket made of similar segments will only be able to flex in one direction from the plane of the blanket. If all the segments taper from the median zone to each end, the resulting blanket may flex in two directions from the plane of the blanket. In many cases the appropriate form for the blanket is a combination of different shaped and arranged segments so that in some areas the blanket can only flex in one direction, in others in only one opposite direction and, in others in two directions.

20 The segments are typically bonded one to another by rope means extending between adjacent segments.

25 The rope means preferably forms an interwoven network extending throughout the blanket and embedded in the material of each segment.

30 The rope means are, preferably plastics material, advantageously nylon, polypropylene or polyester.

Each segment may comprise a solid block of a mixture of

an aggregate, a filler and a binder. The preferred aggregate may be stone, granite, magnetite or haemetite. The preferred fillers and binders are crushed limestone, cement and epoxy resin.

- 5 However it is preferred that each segment comprises a plastics shell filled with a dense material such as concrete to give the required weight and density. The shell is preferably blow-moulded and is preferably polyethylene.

- 10 The shells serve to facilitate control of the positioning of the rope network during manufacture. They also reduce friction between the segment surfaces and at rope transitions. In addition to strengthening the concrete by retarding the set, they provide additional surface protection, are more comfortable to handle and retard marine growth. The polyethylene gives a much
15 more sympathetic surface to contact adjoining pipe lines, structures or equipment.

The segments may taper at an included angle in the region of 25° to 30°.

- 20 The blanket may comprise a variety of layers, some of which need not extend over the entire area of the blanket.

- 25 The blanket is preferably bendable about a radius of greater than 200mm. For "over-bend", when one blanket bends over a pipe the preferred minimum radius is 200mm and for "sag-bend", when the blanket sags the preferred minimum radius is 400mm.

- 30 According to a second aspect of the invention there is provided a method of making a flexible blanket for protection or stabilisation of underwater structures and pipe lines, the method comprising the steps of providing a plurality of hollow plastic shells, each shell tapering substantially regularly from a maximum cross section at a median zone of their height dimension

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to a minimum cross section at one or both ends thereof, arranging said shells in a layer one segment in height, in which the shells have their edges at said median zone substantially contiguous, threading through pre-moulded bores in the shells an interwoven network of rope means whereby each plastics shell is connected by a part of said network to each adjacent plastics shell and filling the shells with a settable composition material, such that the segments are held substantially contiguously but are free to pivot relative one to another about the rope means insofar as is permitted by the taper of the shells, the arrangement of the tapers being such that each segment is capable of pivoting with more than one degree of freedom.

Embodiments of the present invention will now be more particularly described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a segment for use in a blanket embodying the invention;

Figure 2 is a perspective view of an alternative form of segment for use in a blanket embodying the invention;

Figure 3 is a schematic plan view of a blanket embodying the invention;

Figure 4 shows a multi-layer blanket embodying the invention in use;

Figure 5 shows another form of multi-layer blanket in use;

Figure 6 shows a continuous length of blanket in typical installation procedure;

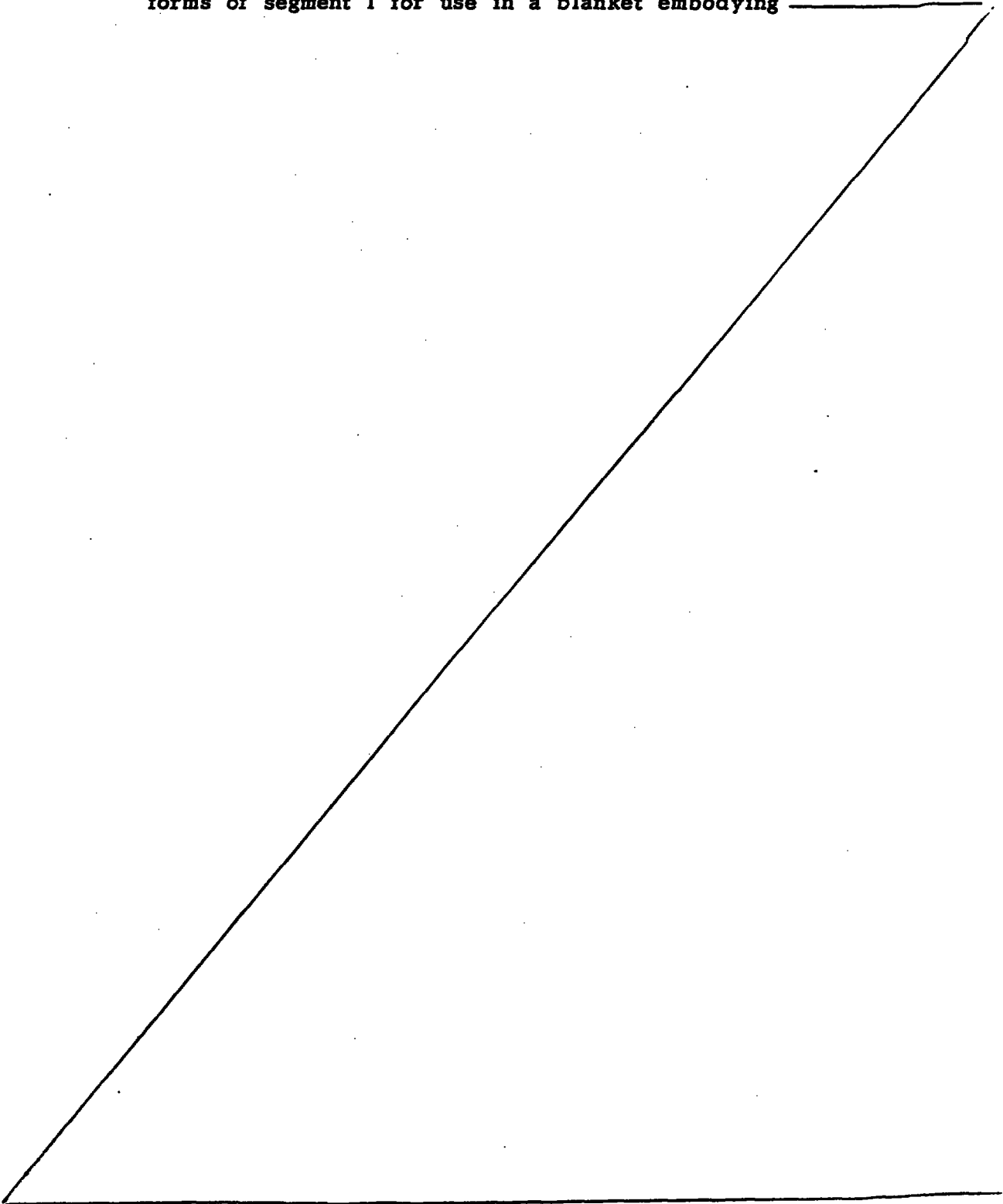
Figure 7 shows blankets laid contiguously in the form of surface paving;

Figure 8 is a perspective view of a further form of segment for use in a blanket embodying the invention; and



Figure 9 is a section through the segment of Figure 8.

Referring now to the drawings, Figures 1 and 2 show alternative forms of segment 1 for use in a blanket embodying



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the invention. Each segment has a waist portion 2 where the segment is of maximum cross-sectional area. It is at this point that each segment touches the next adjacent segment in the blanket. The segment shown in Figure 1 is parallel-sided at one end and tapered at an angle between 25° and 30° toward the other end. This enables a blanket made of such segments to either sag-bend or over-bend depending on which way up the segments are used. The segment shown in Figure 2 tapers from the waist portion 2 toward each end to an equal degree. Such segments can be used to make a blanket which will both sag-bend and over-bend as is required.

The segments are ideally 100mm side length at the waist, have a total height between 150mm and 200mm, a taper of 20mm - 25mm and are adapted to bend around radii down to approximately 200 mm in overbend, and down to approximately 400 mm in sagbend.

The segments are constructed from a settable compound comprising an aggregate, a filler and a binder. Materials which may be used are stone, granite, magnetite, haematite, sand, crushed limestone, cement and/or epoxy resin.

The blankets have a variety of functions. One is to act as a ballast to hold pipe lines or structures in place in which case their prime characteristic is a high density. In such cases, the heaviest possible filler, such as haematite, is used and the product density may be as high as 3.7 tonnes/m³. Alternatively, the blanket may be provided to protect against anchor or construction line sawing in which case hardness is the prime characteristic required. In this case, a hard filler, such as granite is used, and the hardness may be as high as 7 on the Mohs scale. In some circumstances, both density and hardness may be required in which case a compromise is reached between the characteristics.



A third example of a segment is shown in Figures 8 and 9. The segment comprises a blow-moulded polyethylene shell 12 filled with concrete 13. The shell 12 has a hole 14 through which it is filled to hold the rope 15 in place.

- 5 The Polyethylene shell 12 gives the segment a hardwearing surface which will not damage pipe lines, whilst the concrete filling 13 gives the high density required.

A blanket is made from these segments by providing a plurality of shells 12 arranged with their edges substantially contiguous. Each of the shells 12 has 6 holes bored in it to accommodate the rope network 15. The rope 15 are threaded through the holes so that each plastic shell 12 is connected by a part of the rope network to each adjacent plastics shell. The shells 12 are then filled with concrete through holes 14 which sets to hold the ropes 15 in place.



The segments are formed into a blanket as shown in Figure 3. They are arranged with their waist portions 2 touching and are held together by a network of ropes. Longitudinal lifting ropes 3 extend parallelly through the blanket and are 10mm to 20mm thick three-strand nylon for individual blankets depending on length and up to 48mm thick for continuous blanket lengths. The blanket may be lifted by means of these ropes either by both ends or by a single end. Each of these lifting ropes 3 extends through a line of segments. Each line of segments is connected to the next adjacent line by criss-crossing linking ropes 5. These linking ropes are generally 4mm to 7mm diameter three-strand nylon and extend diagonally through the blanket. At the edges of the blanket, they emerge from the segments in the form of loops 4.

Preferred individual blanket sizes are between 2.4m and 10.0m wide and between 6.5m and 19.5 m long. This is a convenient size for lifting and transportation. However, for certain applications such as continuous pipe cover the blanket is produced in longer lengths and supplied on reels which can be attached to suitable vessels for installation as shown in Figure 6.

Figure 4 shows one method of using the blanket. Pipe line 6 is ballasted by a multi-layer blanket in which the layers are held together at the loops 4. The lowermost layer 7 is the primary layer by which the entire assembly can be lifted. The outermost part 8 of this primary layer forms a scour skirt to adapt to changes in condition of the sea bed which may be caused by the introduction of the pipe line and its effect on water currents. At the central part 9 of the blanket, there is again only the primary layer since bulk here may tend to facilitate snagging and dislodgement of individual blankets by anchors, trawl boards etc. Between the outermost part 8 and the central part 9 are a number of secondary layers 10 adapted to provide weight at the points where it will most advantageously hold the pipe line in position.



Figure 5 shows an alternative form in which two layers 7 and 11 are provided each of identical width but the upper layer being of reduced length. A shear membrane (not shown) is provided between the layers to enable relative movement between them and accommodate the over-bend and sag-bend differentials.

Figure 6 shows the installation of a continuous length of blanket which would be particularly advantageous where mechanical protection is paramount. In this format snagging contingency and dislodgement is virtually eliminated.

Figure 7 shows the blanket laid in contiguous paving on the sea bed enabling the perimeter to operate as a scour skirt to protect the elevation of the inner area for use as a constant elevation slip-pad under, for example a pipe line expansion loop or as a protected foundation raft for super-imposed structures, pipe lines, equipment and the like.

Blankets made of segments shown in figures 1 and 2 are manufactured by providing either a number of lower half-moulds which are assembled in continuous relationship or by providing a multi-form lower half-mould having a plurality of pockets. The lifting ropes 3 and linking ropes 5 are interwoven and laid out on top of the lower half-mould and a corresponding upper half placed in position. The material is then cast into the mould thereby embedding the ropes. If so desired, the ropes can be welded or clamped together at their crossing points at the centre of each segment.

As stated above, the ideal shape for each segment is, in plan view, a regular hexagon. This enables flexibility in any direction and also helps prevent sawing by anchor cables or construction lines since there are no straight line joins through which the sawing can be facilitated.

The blankets have been more specifically described in relation to stabilisation and protection of underwater

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structures and pipe lines, but other uses, both underwater and on land are intended. For example, the combination of integrated tie ropes at a point where they are protected from damage, and in a manner whereby structural integrity is not impaired by accidental destruction of one or more of the segments or its relative tie ropes, together with the multi-directional ductility of the blanket makes it ideal for paving any unstable surface.

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Also the use of 150mm and 200mm high segments in alternative horizontal rows on tidal embankments would afford unsurpassed resistance to tidal run-up which, together with its structural integrity, makes the blanket superior to alternative forms of protection for coastal and inland water embankments.

CLAIMS

1. A flexible blanket for protection or stabilisation of underwater structures and pipe lines, unstable beds and embankments, the blanket comprising a plurality of segments arranged in one or more layers each one segment in height, the segments of the or each layer being disposed substantially contiguously at least at a median zone of their height dimension, each segment tapering substantially regularly from a maximum cross section at said median zone to a minimum cross section at one or both ends thereof and each segment being so bonded to each adjacent segment in the region of their respective median zones that the segments are held substantially contiguously but are free to pivot relative one to another about the bond in so far as is permitted by said taper, the arrangement of the tapers being such that each segment is capable of pivoting with more than one degree of freedom.
2. A blanket according to Claim 1, in which each segment is, in plan view, a regular polygon.
3. A blanket according to Claim 2, in which each segment is, in plan view, a regular hexagon.
4. A blanket according to any of the preceding claims, including segments which taper from the median zone to one end only, the other end being parallel-sided.
5. A blanket according to any of the preceding claims, including segments which taper from the median zone toward each end.
6. A blanket according to any of the preceding claims, in which the segments are bonded one to another by rope means extending between adjacent segments.
7. A blanket according to Claim 6, in which the rope means forms an interwoven network extending throughout



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the blanket, and is embedded in the material of each segment.

8. A blanket according to Claim 6 or 7, in which the rope means are plastics material, advantageously nylon, polypropylene or polyester.

5 9. A blanket according to any of the preceding claims, in which each segment comprises a block of a mixture of an aggregate, a filler and a binder.

10. A blanket according to Claim 9, in which the aggregate may be stone, granite, magnetite or haemetite.

10 11. A blanket according to Claim 9 or 10, in which the fillers and binders are crushed limestone, cement and epoxy resin.

15 12. A blanket according to any one of Claims 1 to 8, in which each segment comprises a plastics shell filled with a dense filler such as concrete.

13. A blanket according to any one of the preceding claims, in which the segments taper at an included angle in the region of 25° to 30°.

20 14. A blanket according to any one of the preceding claims, which comprises a variety of layers, some of which may not extend over the entire area of the blanket.

15. A blanket according to any of the preceding claims, which is bendable about a radius greater than 200 mm in any direction.

25 16. A flexible blanket for protection or stabilisation of underwater structures and pipe lines, unstable beds and embankments arranged substantially as described herein with reference to and illustrated in Figure 1 of the accompanying drawings.



17. A flexible blanket for protection or stabilisation of underwater structures and pipe lines, unstable beds and embankments arranged substantially as described herein, with reference to and as illustrated in Figure 2 and 3 of the accompanying drawings.

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18. A flexible blanket for protection or stabilisation of underwater structures and pipe lines, unstable beds and embankments, arranged substantially as described herein with reference to, and as illustrated in, Figure 4 of the accompanying drawings

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19. A flexible blanket for protection or stabilisation of underwater structures and pipe lines, unstable beds and embankments, arranged substantially as described herein with reference to and as illustrated in Figure 5 of the accompanying drawings.

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20. A flexible blanket for protection or stabilisation of underwater structures and pipe lines, unstable beds and embankments, arranged substantially as described herein with reference to, and as illustrated in Figures 8 and 9 of the accompanying drawings.

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21. A method of making a flexible blanket for protection or stabilisation of underwater structures and pipe lines, the method comprising the steps of providing a plurality of hollow plastic shells, each shell tapering substantially regularly from a maximum cross section at a median zone of their height dimension to a minimum cross section at one or both ends thereof, arranging said shells in a layer one segment in height, in which the shells have their edges at said median zone substantially contiguous, threading through pre-moulded bores in the shells an interwoven network of rope means whereby each plastics shell is connected by a part of said network to each adjacent plastics shell and filling the shells with a settable composition material, such that the segments are held substantially contiguously but are free to pivot relative one to another about the rope

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means insofar as is permitted by the taper of the shells,
the arrangement of the tapers being such that each segment
is capable of pivoting with more than one degree of freedom.

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