CLAIMS

1. A treatment device ~~(10, 100)~~ for treating a portion of soil ~~(ST)~~, the device comprising:

· a rotary shaft ~~(20, 120)~~ extending along a main axis ~~(X)~~ and presenting a top end ~~(26)~~ pointing upstream and a bottom end ~~(28)~~ pointing downstream;

· at least one deployable mixer tool ~~(40)~~ fastened to the rotary shaft ~~(20, 120)~~ in the vicinity of its bottom end ~~(28)~~; and

· a longitudinal pipe ~~(22)~~ for injecting a fluid into the proximity of the bottom end of the rotary shaft ~~(20, 120)~~;

~~the device being characterized in that it further comprises:~~

· a boring tool ~~(24)~~ situated at the bottom end of the shaft;

· an outer tubular element ~~(30, 130)~~ extending along an axis parallel to the main axis ~~(X)~~ of the rotary shaft ~~(20, 120)~~, the rotary shaft ~~(20, 120)~~ being arranged inside said tubular element ~~(30, 130)~~; and

· a coupling system ~~(50, 150)~~ between the rotary shaft ~~(20, 120)~~ and the tubular element ~~(30, 130)~~, said coupling system ~~(50, 150)~~ being suitable in a first configuration for constraining the tubular element ~~(30, 130)~~ and the rotary shaft ~~(20, 120)~~ to move together in rotation about the main axis ~~(X)~~, in at least one direction of rotation, and for constraining the tubular element ~~(30, 130)~~ and the rotary shaft ~~(20, 120)~~ to move together in translation along the main axis ~~(X)~~, at least in the downstream direction, and said coupling system ~~(50, 150)~~ being suitable in a second configuration for releasing said movement in rotation and in translation.

2. A treatment device ~~(10, 100)~~ according to claim 1, wherein the mixer tool ~~(40)~~ is housed in the tubular element ~~(30, 130)~~ when the coupling system ~~(50, 150)~~ is in its first configuration.

3. A treatment device ~~(10, 100)~~ according to claim 1 or claim 2, wherein the mixer tool ~~(40)~~ is adapted to be extracted from the tubular element ~~(30, 130)~~ and to be introduced into a portion of soil to be treated ~~(ST)~~ when the coupling system ~~(50, 150)~~ is in its second configuration.

4. A treatment device ~~(10, 100)~~ according to any one of claims 1 to 3, wherein the coupling system ~~(50, 150)~~ is a bayonet system.

5. A treatment device ~~(10, 100)~~ according to claim 4, wherein the coupling system ~~(50)~~ includes at least one lug ~~(54)~~ formed on the inside face of the tubular element ~~(30)~~ and a corresponding number of catches ~~(52)~~ formed on the rotary shaft ~~(20)~~, each lug ~~(54)~~ being adapted to come into abutment radially and axially against a catch ~~(52)~~.

6. A treatment device ~~(10, 100)~~ according to any one of claims 1 to 5, wherein the deployable mixer tool ~~(40)~~ comprises at least one deployable mixer arm ~~(42)~~ fastened to the bottom end ~~(28)~~ of the rotary shaft ~~(20, 120)~~ and extending laterally relative to the main direction ~~(X)~~ of the shaft ~~(20, 120)~~, said arm ~~(42)~~ presenting a deployed position and a retracted position, such that in the deployed position the span of the mixer tool ~~(40)~~ is greater than the outside diameter of the tubular element ~~(30, 130)~~ to enable the portion of soil ~~(ST)~~ to be treated by rotating the shaft ~~(20, 120)~~, and in the retracted position, the mixer tool ~~(40)~~ is suitable for being inserted inside the tubular element ~~(30, 130)~~.

7. A treatment device ~~(10, 100)~~ according to claim 6, wherein the mixer tool ~~(40)~~ further includes spring means ~~(44)~~ suitable for causing the mixer arm ~~(42)~~ to deploy

out from the tubular element ~~(30)~~ and for enabling it to return into its retracted position while the bottom portion ~~(28)~~ of the shaft ~~(20, 120)~~ is being inserted in the tubular element ~~(30, 130)~~.

8. A treatment device ~~(10, 100)~~ according to any one of claims 1 to 7, wherein the coupling system ~~(50, 150)~~ is suitable for constraining the tubular element ~~(30, 130)~~ and the rotary shaft ~~(20, 120)~~ to move together in rotation about the main axis ~~(X)~~ in both directions of rotation.

9. A treatment device ~~(10, 100)~~ according to any one of claims 1 to 8, wherein the coupling system ~~(50, 150)~~ is also adapted to constrain the tubular element ~~(30, 130)~~ and the rotary shaft ~~(20, 120)~~ to move together in translation along the main axis ~~(X)~~ in the upstream direction.

10. A treatment device ~~(10, 100)~~ according to claim 9, wherein the coupling system ~~(50)~~ further includes abutment means ~~(56)~~ adapted to co-operate with the rotary shaft ~~(20)~~ so that the rotary shaft ~~(20)~~ and the tubular element ~~(30)~~ are constrained to move together in translation in the upstream direction regardless of the angular position of the rotary shaft ~~(20)~~.

11. A treatment device ~~(10, 100)~~ according to claim 10, wherein the abutment means ~~(56)~~ comprise a collar formed on the inside face of the tubular element ~~(30)~~, the inside diameter of said collar ~~(56)~~ being smaller than the maximum diameter of the rotary shaft ~~(20)~~ on the portion of said shaft ~~(20)~~ that is situated downstream from said collar ~~(56)~~.

12. A treatment device ~~(10, 100)~~ according to any one of claims 1 to 11, including at least two mixer devices ~~(40)~~ that are spaced apart axially along the main axis ~~(X)~~.

13. A treatment device ~~(10, 100)~~ according to any one of claims 1 to 12, wherein the coupling system ~~(50)~~ is provided in the vicinity of the bottom end ~~(28)~~ of the rotary shaft ~~(20)~~ and of the tubular element ~~(30)~~.

14. A method of treating a portion of soil, wherein a treatment device ~~(10, 100)~~ according to any one of claims 1 to 13 is provided, said method further comprising at least the following steps:

· constraining the tubular element ~~(30, 130)~~ and the rotary shaft ~~(20, 120)~~ to move together by bringing the coupling system ~~(50, 150)~~ into its first configuration;

· lowering the rotary shaft ~~(20, 120)~~ into the soil (S) together with the tubular element ~~(30, 130)~~ until reaching the portion of soil to be treated ~~(ST)~~;

· unconstraining the rotary shaft ~~(20, 120)~~ and the tubular element ~~(30, 130)~~ by bringing the coupling system ~~(50, 150)~~ into its second configuration;

· moving the rotary shaft ~~(20, 120)~~ relative to the tubular element ~~(30, 130)~~ until the mixer tool ~~(40)~~ is inserted into the portion of soil for treatment ~~(ST)~~;

· deploying the mixer tool ~~(40)~~; and

· rotating the shaft ~~(20, 120)~~ while injecting a fluid into the portion of soil via the longitudinal pipe ~~(22)~~, whereby the portion of soil ~~(ST)~~ is mixed with said fluid.

15. A method of treating a portion of soil according to claim 14, wherein, after the portion of soil ~~(ST)~~ has been treated, the tubular element ~~(30, 130)~~ is extracted from the soil together with the rotary shaft ~~(20, 120)~~.