## CLAIMS

1. A head (10) for injecting consolidating pressurised fluid mixtures into the ground in order to form consolidated soil portions, the head including:

- an outer cylindrical body (12) defining a central, longitudinal axis (Z),
- at least one upper inlet (16) for receiving fluids from a string of tubular rods mountable above the head,
- at least one outlet side nozzle (11) lying in a plane substantially perpendicular to the longitudinal axis (Z),
- at least one helical duct (13), defining a helical central line (m), the duct (13) connecting the upper inlet (16) to the nozzle (11) so as to impart the fluid flowing through it a helical motion about the longitudinal axis (Z) towards the nozzle (11);

characterised in that the helical duct (13) is progressively tapered towards the nozzle (11) and includes a terminal length of the duct which is radiused to the nozzle in a tapered manner, both when viewed in cross-sectional planes (P) parallel to the longitudinal axis (Z) and tangent to the helical central line, as well as when viewed in cross-sectional planes perpendicular to the axis (Z).

2. An injection head according to claim 1, characterised in that the helical duct (13) is radiused to the upper inlet (16) in such manner that at that radiused zone the longitudinal axis (Z) forms an acute angle not exceeding 30° with a straight line tangent to the central helical line (m) of the duct (13).

3. An injection head according to claim 1 or 2, characterised in that:

a) the radius (r) of the helix is substantially constant or increases linearly or decreases linearly from the inlet (16) to the outlet nozzle (11);

b) the helical pitch or the helix angle ($\alpha$) decreases constantly from the inlet (16) to the outlet nozzle (11); and

c) the area of the cross-section of the duct (13) perpendicular to the central line (m) decreases linearly from the inlet (16) to the outlet nozzle (11).

4. An injection head according to any one of claims 1 to 3, characterised in that the helix angle ($\alpha$) at the inlet (16) ranges between about 60° and about 90°, and is preferably about 70°.

5. An injection head according to any one of the preceding claims, characterised in that the half-angle ($\delta$) by which the helical duct (13) is tapered is comprised between about 5° and about 15°.

6. An injection head according to any one of the preceding claims, characterised in that said at least one helical duct (13) is delimited:

- internally or towards the longitudinal axis (Z), by a cylindrical surface (20) of a central tubular core (19) having an axial central cavity (21) for the passage of a fluid, and
- externally or peripherally, by the inner cylindrical surface (15b) of the outer body (12) in which there is fixed a rigid body (17) forming at least one helical channel providing a pair of facing helical surfaces, of which an upper one (14a) and a lower one (14b).

7. An injection head according to any one of the preceding claims, characterised in that:

- the helical duct (13) has a transverse cross-section of polygonal shape, particularly rectangular,
- the relevant nozzle (11) has a circular cross-section, and that
- in said terminal length, the helical duct (13) is radiused to the nozzle (11) by at least one deflector (25), the deflector defining a polygonal inlet having a shape congruent to that of the cross-section of the duct (13) in that radiused point, a circular outlet congruent to that of the nozzle (11) and an intermediate length passing gradually from the polygonal cross-section to the circular cross-section.

8. An injection head according to claim 7, characterised in that within the helical duct (13), immediately upstream of the nozzle (11), there is fixed or formed a deflector (25) having an arched surface (25a) facing the inside of the duct and suitable for deviating progressively the fluid flow from a peripheral zone, adjacent to the peripheral side surface (15b) of the duct (13), to a more central zone, where the end of the arched surface (25a)

located more downstream is radiused uniformly to the inlet of the nozzle (11).

9. An injection head according to claim 7 or 8, characterised in that the deflector (25) is made of a wear-resistant material, for example Widia or tungsten carbide, or sintered materials.

10. An injection head according to any one of the preceding claims, characterised in that the helical shape of each duct (13) is defined by a pair of facing helical surfaces, which include an upper (14a) one and a lower (14b) one, both formed by a rigid helical body (17) secured within an inner cylindrical cavity (15b) of a sleeve constituting the outer cylindrical body (12).

11. An injection head according to claim 10, characterised by comprising sealing means (26) interposed between the inner helical body (17) and the inner surface (15b) of the sleeve (12).

12. An injection head according to claim 10 or 11, characterised in that the deflector (25) consists of a rigid arched element fixed within the helical duct (13), and having an outer cylindrical surface (25b) contacting the inner cylindrical surface (15b) of the sleeve (12), and that the deflector gradually increases in thickness, in such manner that the arched inner surface (25a) starts from a thinner end portion (25c), located more upstream in the duct (13), and terminates with a thicker end portion (25d) located more downstream, at the inlet of the nozzle (11).

## CLAIMS

1. A head (10) for injecting consolidating pressurised fluid mixtures into the ground in order to form consolidated soil portions, the head including:

- an outer cylindrical body (12) defining a central, longitudinal axis (Z),
- at least one upper inlet (16) for receiving fluids from a string of tubular rods mountable above the head,
- at least one outlet side nozzle (11) lying in a plane substantially perpendicular to the longitudinal axis (Z),
- at least one helical duct (13), defining a helical central line (m), the duct (13) connecting the upper inlet (16) to the nozzle (11) so as to impart the fluid flowing through it a helical motion about the longitudinal axis (Z) towards the nozzle (11), the helical duct (13) being progressively tapered towards the nozzle (11) and including a terminal length of the duct which is radiused to the nozzle in a tapered manner, both when viewed in cross-sectional planes (P) parallel to the longitudinal axis (Z) and tangent to the helical central line, as well as when viewed in cross-sectional planes perpendicular to the axis (Z);

characterised in that said at least one helical duct (13) is delimited:

- internally or towards the longitudinal axis (Z), by a cylindrical surface (20) of a central tubular core (19) having an axial central cavity (21) for the passage of a fluid, and
- externally or peripherally, by the inner cylindrical surface (15b) of the outer body (12) in which there is fixed a rigid body (17) forming at least one helical channel providing a pair of facing helical surfaces, of which an upper one (14a) and a lower one (14b).

2. An injection head according to claim 1, characterised in that the helical duct (13) is radiused to the upper inlet (16) in such manner that at that radiused zone the longitudinal axis (Z) forms an acute angle not exceeding 30° with a straight line tangent to the central helical line (m) of the duct (13).

3. An injection head according to claim 1 or 2, characterised in that:

a) the radius (r) of the helix is substantially constant or increases linearly or decreases linearly from the inlet (16) to the outlet nozzle (11);

b) the helical pitch or the helix angle ($\alpha$) decreases constantly from the inlet (16) to the outlet nozzle (11); and

c) the area of the cross-section of the duct (13) perpendicular to the central line (m) decreases linearly from the inlet (16) to the outlet nozzle (11).

4. An injection head according to any one of claims 1 to 3, characterised in that the helix angle ($\alpha$) at the inlet (16) ranges between about 60° and about 90°, and is preferably about 70°.

5. An injection head according to any one of the preceding claims, characterised in that the half-angle ($\delta$) by which the helical duct (13) is tapered is comprised between about 5° and about 15°.

6. An injection head according to any one of the preceding claims, characterised in that:

- the helical duct (13) has a transverse cross-section of polygonal shape, particularly rectangular,
- the relevant nozzle (11) has a circular cross-section, and that
- in said terminal length, the helical duct (13) is radiused to the nozzle (11) by at least one deflector (25), the deflector defining a polygonal inlet having a shape congruent to that of the cross-section of the duct (13) in that radiused point, a circular outlet congruent to that of the nozzle (11) and an intermediate length passing gradually from the polygonal cross-section to the circular cross-section.

7. An injection head according to claim 6, characterised in that within the helical duct (13), immediately upstream of the nozzle (11), there is fixed or formed a deflector (25) having an arched surface (25a) facing the inside of the duct and suitable for deviating progressively the fluid flow from a peripheral zone, adjacent to the peripheral side surface (15b) of the duct (13), to a more central zone, where the end of the arched surface (25a) located more downstream is radiused uniformly to the inlet of the nozzle (11).

8. An injection head according to claim 6 or 7, characterised in that the deflector (25) is made of a wear-resistant material, for example Widia or tungsten carbide, or sintered

materials.

9. An injection head according to any one of the preceding claims, characterised in that the helical shape of each duct (13) is defined by a pair of facing helical surfaces, which include an upper (14a) one and a lower (14b) one, both formed by a rigid helical body (17) secured within an inner cylindrical cavity (15b) of a sleeve constituting the outer cylindrical body (12).

10. An injection head according to claim 9, characterised by comprising sealing means (26) interposed between the inner helical body (17) and the inner surface (15b) of the sleeve (12).

11. An injection head according to claim 9 or 10, characterised in that the deflector (25) consists of a rigid arched element fixed within the helical duct (13), and having an outer cylindrical surface (25b) contacting the inner cylindrical surface (15b) of the sleeve (12), and that the deflector gradually increases in thickness, in such manner that the arched inner surface (25a) starts from a thinner end portion (25c), located more upstream in the duct (13), and terminates with a thicker end portion (25d) located more downstream, at the inlet of the nozzle (11).