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(* APPENDIX 2 *)
(* Select all and copy of this paper,
and paste on the MATHEMATICA in TEXT type,
then MATHEMATICA program will be run. *)

(* The ruled surface Ω of the T.C.R. by generator lines *)

Off[General::spell]
r = 1.0;
(* "r" is a radius of the T.C.R., and any value is permitted,
          1.0 is an example. *)
δo = ArcSin[1/(1 + Sqrt[2])];
tend = Pi/2 + δo;
(* "tend" is a terminal value of the parameter "t" *)

(* The segment circle Ca based on (3). *)
s = Sin[t];
c = Cos[t];

xa[t_] := r*s
ya[t_] := -r*(Sqrt[2]/2 + c)
za[t_] := 0.

(* The segment circle Cb based on (6) *)
xb[t_] := 0.
yb[t_] := r*Sqrt[2]/(2 + 2*Sqrt[2]*c)
zbp[t_] := r*Sqrt[(Sqrt[2] + c)^2 - 1]/
     (1 + Sqrt[2]*c) (* In the case of z > 0 *)
zbm[t_] := -zbp[t]  (* In the case of z < 0 *)


(* The segment circle Ca based on (71) *)
sτ = Sin[τ];
cτ = Cos[τ];

xaτp[τ_] := r*Sqrt[(Sqrt[2] + cτ)^2 - 1]/
     (1 + Sqrt[2]*cτ)      (* In the case of x > 0 *)
xaτm[τ_] := -xaτp[τ]     (* In the case of x < 0 *)
yaτ[τ_] := -r/(Sqrt[2] + 2*cτ)
zaτ[τ_] := 0.
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(* The segment circle Cb based on (70) *)
xbτ[τ_] := 0.
ybτ[τ_] := r*(Sqrt[2]/2 + cτ)
zbτ[τ_] := r*sτ

(* The ruled - surface Ω based on (3), (6) and (70), (71) *)
inc = (Pi/2)/9.;

labp = Table[{{xa[t], ya[t], za[t]}, {xb[t], yb[t], zbp[t]}},
{t, -Pi/2, Pi/2,inc}];
labm = Table[{{xa[t], ya[t], za[t]}, {xb[t], yb[t], zbm[t]}},
{t, -Pi/2, Pi/2,inc}];
lbap = Table[{{xaτp[τ], yaτ[τ], zaτ[τ]}, {xbτ[τ], ybτ[τ],
        zbτ[τ]}}, {τ, -Pi/2, Pi/2, inc}];
lbam = Table[{{xaτm[τ], yaτ[τ], zaτ[τ]}, {xbτ[τ], ybτ[τ],
        zbτ[τ]}}, {τ, -Pi/2, Pi/2, inc}];
nolab = Length[labp];

(* The "Ω2" is a upper surface of the "Ω" for "t"
     which is in between - Pi/2 and Pi/2  *)

Ω2 = Show[Graphics3D[Table[Line[labp[[i]]], {i, 1, nolab}]],
   PlotRange -> {{-1.2r, 1.2r}, {-1.2r(1 + Sqrt[2]/2),
        1.2r(1 + Sqrt[2]/2)}, {-1.2r, 1.2r}}, DisplayFunction -> Identity]

(* The "Ω3" is a right surface of the "Ω" for "τ"
     which is in between - Pi/2 and Pi/2  *)
Ω3 = Show[Graphics3D[Table[Line[lbap[[i]]], {i, 1, nolab}]],
   PlotRange -> {{-1.2r, 1.2r},
{-1.2r(1 + Sqrt[2]/2),  1.2r(1 + Sqrt[2]/2)}, {-1.2r, 1.2r}},
 DisplayFunction -> Identity]

(* The "Ω1" is a lower surface of the "Ω" for "t"
     which is in between - Pi/2 and Pi/2  *)
Ω1 = Show[Graphics3D[Table[Line[labm[[i]]], {i, 1, nolab}]],
   PlotRange -> {{-1.2r, 1.2r},
{-1.2r(1 + Sqrt[2]/2),  1.2r(1 + Sqrt[2]/2)}, {-1.2r, 1.2r}},
 DisplayFunction -> Identity]
```

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(* The "Ω4" is a left surface of the "Ω" for "τ"
     which is in between - Pi/2 and Pi/2  *)
Ω4 = Show[Graphics3D[Table[Line[lbam[[i]]], {i, 1, nolab}]],
    PlotRange -> {{-1.2r, 1.2r},
{-1.2r(1 + Sqrt[2]/2), 1.2r(1 + Sqrt[2]/2)}, {-1.2r, 1.2r}},
DisplayFunction -> Identity]

(* Circle A and B *)
ca = ParametricPlot3D[{xa[t], ya[t], za[t]}, {t , -tend, tend},
    DisplayFunction -> Identity]
cb = ParametricPlot3D[{0, r*(Sqrt[2]/2 + cτ), r* sτ}, {τ, -tend, tend},
    DisplayFunction -> Identity]
cacb = Show[ca, cb, DisplayFunction -> Identity]

(* Coordinate axis x y z *)
lx = Show[Graphics3D[{AbsoluteThickness[1.2],
        Line[{{-0.5*r, 0, 0}, {1.2*r, 0, 0}}]}], DisplayFunction -> Identity]
ly = Show[Graphics3D[{AbsoluteThickness[1.2],
        Line[{{0, -1.0* r*(1 + Sqrt[2]/2), 0},
{0, 1.2*r*(1 + Sqrt[2]/2), 0}}]}], DisplayFunction -> Identity]
lz = Show[Graphics3D[{AbsoluteThickness[1.2],
        Line[{{0, 0, -0.5*r}, {0, 0, 1.5*r}}]}], DisplayFunction -> Identity]

(* Center lines of the Ca and Cb *)
lxca = Show[Graphics3D[Line[{{-r, -r*Sqrt[2]/2, 0}, {r, -r*Sqrt[2]/2, 0}}]],
    DisplayFunction -> Identity]
lzca = Show[
    Graphics3D[Line[{{0, -r*Sqrt[2]/2, 0}, {0, -r*Sqrt[2]/2, 0.2*r}}]],
    DisplayFunction -> Identity]
lxcb = Show[
    Graphics3D[Line[{{-0.2*r, r*Sqrt[2]/2, 0}, {0.2*r, r*Sqrt[2]/2, 0}}]],
    DisplayFunction -> Identity]
lzcb = Show[Graphics3D[Line[{{0, r*Sqrt[2]/2, -r}, {0, r*Sqrt[2]/2, r}}]],
    DisplayFunction -> Identity]

(* Sphere G ; It's radius is r/Sqrt[2],
  and a center is origin of the O - xyz coordinate system. *)
```

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```
<< Graphics`Graphics3D`
<< Graphics`Shapes`

g = Show[Graphics3D[Sphere[r*Sqrt[2]/2, 25, 25]], Shading -> False,
   DisplayFunction -> Identity]
wG = Show[WireFrame[g], DisplayFunction -> Identity]

(* The Moving - Centroad Mc *)
xsd = r*s/(2 + Sqrt[2]*c);
ysd = -r*c/(2 + Sqrt[2]*c);
zsd = r*Sqrt[(Sqrt[2] + c)^2 - 1]/(2 + Sqrt[2]*c);
mc = ParametricPlot3D[{{xsd, ysd, zsd, {AbsoluteThickness[2], Hue[0.66]}},
{xsd, ysd, -zsd, {AbsoluteThickness[2], Hue[0.66]}}}, {t, -tend, tend},
   AspectRatio -> Automatic, PlotPoints -> 1000,
   ViewPoint -> {2.962, -1.207, 1.104},
   DisplayFunction -> Identity]

(* The ruled surface Ω by a generator - lines *)
Show[Ω1, Ω2, Ω3, Ω4, wG, mc, cacb,
  lx, ly, lz, lxca, lzca, lxcb, lzcb,
  DisplayFunction -> $DisplayFunction,
  ViewPoint -> {3.015, -2.658, 3.378},
  Shading -> False, Boxed -> False]
```