TPLL01 - Infinite plane wall in linear thermal

Summarized:

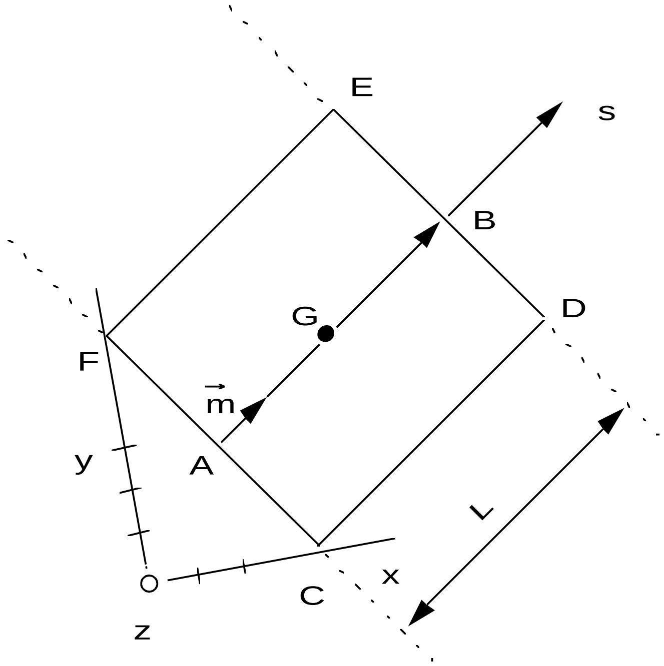
This case test relates to a computation of steady thermal linear. It understands 10 modelizations which test the elements 2D and 3D.

This case test is of several interests:

- **for the modelizations of A with I**, it tests on almost all the elements 3D and 2D (except `2D_AXIS`, `PYRAM` and lumped), the computation of the basic options of linear thermal: "stiffness", "mass", exchanges, imposed flux, imposed temperature,
- **in the modelization J**, one calculates a cartography of spatial error via option `ERTH_ELEM` of `CALC_ERREUR` on which will rest, in a loop Python, tools of refinement/coarsening HOMARD encapsulated in `MACR_ADAP_MAIL`.
- The directional sense of the wall is unspecified compared to the axes of coordinates,
- It is one of the rare benchmarks to test elements TETRA10 and QUAD9 in linear thermal, to combine commands `AFFE_CHAR_THER/LIAISON_DDL`, and to test `INTE_MAIL_3D`.

1 Problem of reference

1.1 Geometry



Le problème correspond à un mur infini :
CF et DE quelconque

$L=0.05\,m$

C={0.03, 0.0, 0.0}
F={0.0, 0.04, 0.0}
A={0.015, 0.02, 0.0}

1.2 Material properties

$\lambda=0.75\,W/m\,°C$ thermal Conductivity

$\rho C_P=2.\,J/m^3\,°C$ voluminal Heat

1.3 Boundary conditions and loadings

- $[FE]$ and $[CD]$: null flux
- $[FA]$: free convection ($h=30\,W/m^2\,°C$, $T^e=140\,°C$)
- $[AC]$: imposed temperature $T^i=100\,°C$
- $[ED]$: density flux imposed $\varphi^i=-1\,200\,W/m^2$, (outgoing flux)

1.4 Initial conditions

to do this steady calculation, one does a transient computation (except for the modelizations A and G) for which the boundary conditions are constant in time. This makes it possible to test elementary computations of mass intervening in the first member as well as the second member.

2 Reference solution

2.1 Method of calculating used for the reference solution

$$T(s)=T_A+(T_B-T_A).\frac{s}{L} \quad S=\overline{AM} \quad M \text{ point courant}$$

$$\vec{\varphi}=-\lambda.\frac{T_B-T_A}{L}.\vec{m}$$

2.2 Results of reference

Temperatures and flux to the points $A \quad B \quad G$.

2.3 Uncertainty on the analytical

solution Solution.

2.4 References

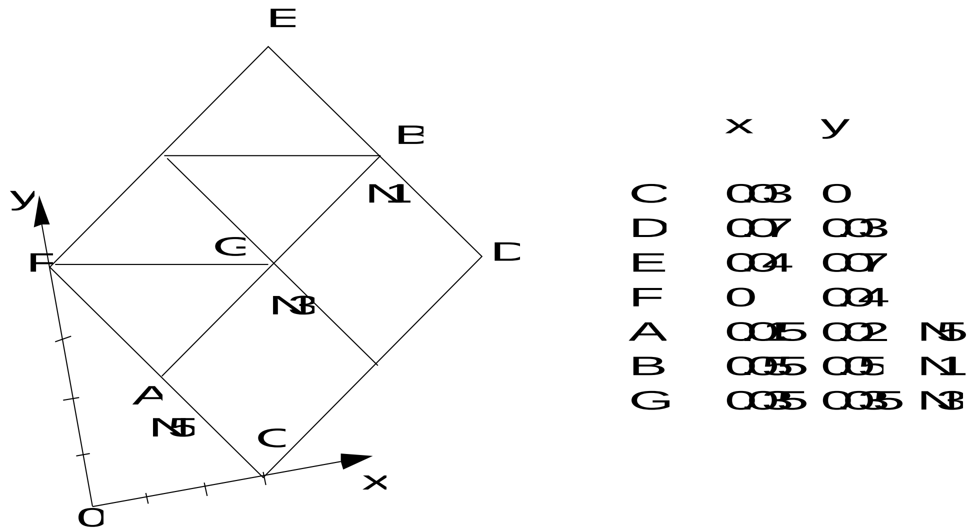
Case test VPCS TPLL01.

3 Modelization A

3.1 Characteristic of the modelization

Plane (QUAD4, TRIA3)

One nets part of the infinite wall, such as the field is a square $\overline{DE}=\overline{CF}=L$ with 4 meshes TRIA3 and 2 meshes QUAD4.



3.2 Characteristics of the mesh

Many nodes: 9

Number of meshes and types: 2 QUAD4, 4 TRIA3

3.3 Remarks

to test factor key word `the LIAISON_DDL`, the linear relation was introduced (checked by the solution): $T(G)-T(B)=40.$

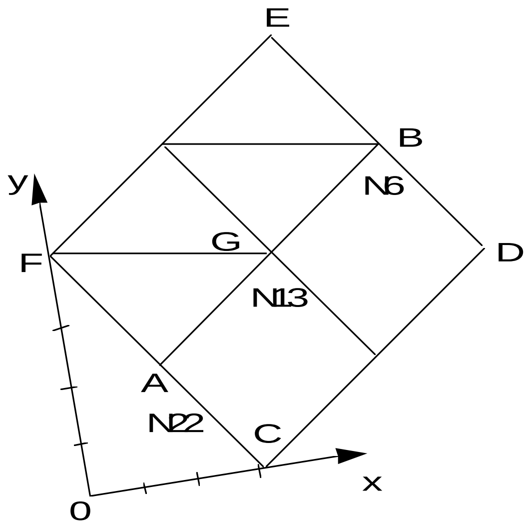
3.4 Values tested

Identification	Reference
$T(A)°C$	100.
$T(B)°C$	20.
$T(G)°C$	60.
$\vec{\varphi}(m).\vec{i}\ (\forall m)\ W/m^2$	960.
$\vec{\varphi}(m).\vec{j}\ (\forall m)\ W/m^2$	720.

4 Modelization B

4.1 Characteristic of the modelization

Plane (QUAD8, TRIA6)



	x	y	
C	0.03	0	
D	0.07	0.03	
E	0.04	0.07	
F	0	0.04	
A	0.015	0.02	N22
B	0.055	0.05	N6
G	0.035	0.035	N13

4.2 Characteristic of the mesh

Many nodes: 23

Number of meshes and types: 4 TRIA6, 2 QUAD8

4.3 Notice

to test the key word factor `LIAISON_DDL` , one introduced the linear relation (checked by the solution) $T(G)-T(B)=40.$

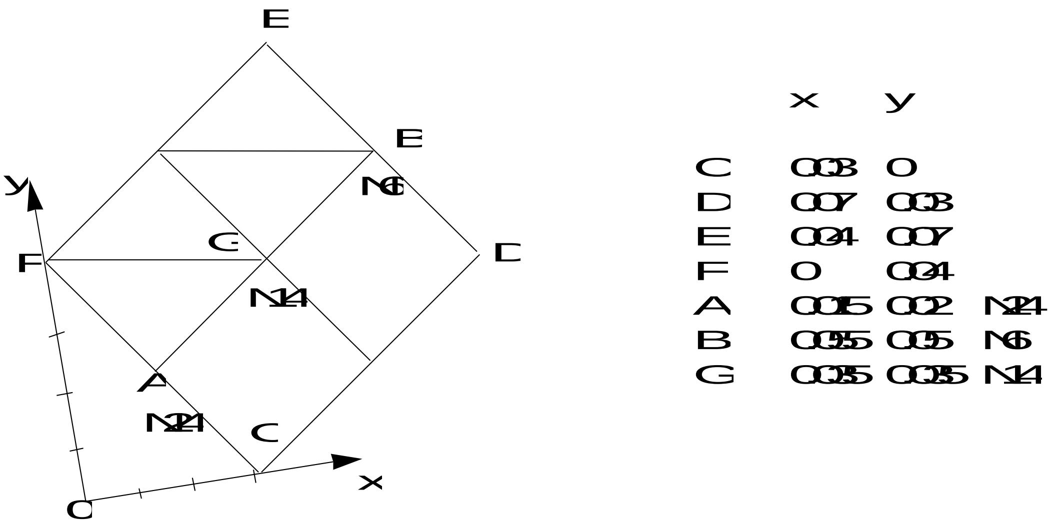
4.4 Values tested

Identification	Reference
$T(A)°C$	100.
$T(B)°C$	20.
$T(G)°C$	60.
$\vec{\varphi}(m).\vec{i}\ (\forall m)\ W/m^2$	960.
$\vec{\varphi}(m).\vec{j}\ (\forall m)\ W/m^2$	720.

5 Modelization C

5.1 Characteristic of the modelization

Plane (QUAD8, TRIA6)



5.2 Characteristic of the mesh

Many nodes: 25

Number of meshes and types: 4 TRIA6, 2 QUAD9

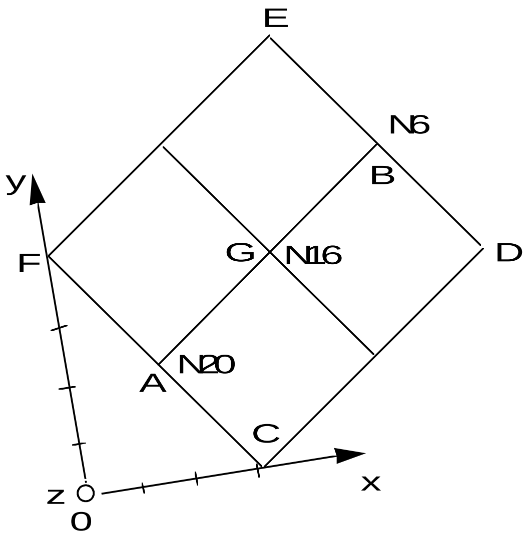
5.3 Values tested

Identification	Reference
$T(A)°C$	100.
$T(B)°C$	20.
$T(G)°C$	60.
$\vec{\varphi}(m).\vec{i}\ (\forall m)\ W/m^2$	960.
$\vec{\varphi}(m).\vec{j}\ (\forall m)\ W/m^2$	720.

6 Modelization D

6.1 Characteristic of the Voluminal

modelization (HEXA8)



	x	y	z	
C	0.03	0	0	
D	0.07	0.03	0	
E	0.04	0.07	0	
F	0	0.04	0	
A	0.015	0.02	0	N20
B	0.055	0.05	0	N6
G	0.035	0.035	0	N16

6.2 Characteristic of the mesh

Many nodes: 21

Number of meshes and types: 4 HEXA8 + 20 QUAD4

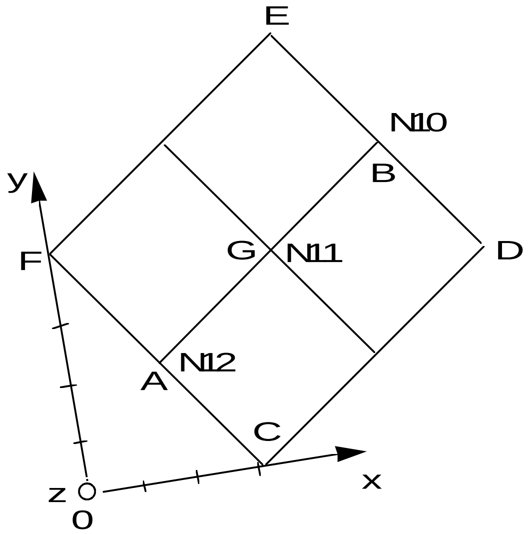
6.3 Values tested

Identification	Reference
$T(A)°C$	100.
$T(B)°C$	20.
$T(G)°C$	60.
$\vec{\varphi}(m).\vec{i}\ (\forall m)\ W/m^2$	960.
$\vec{\varphi}(m).\vec{j}\ (\forall m)\ W/m^2$	720.

7 Modelization E

7.1 Characteristic of the Voluminal

modelization (PENTA6)



	x	y	z	
C	0.03	0	0	
D	0.07	0.03	0	
E	0.04	0.07	0	
F	0	0.04	0	
A	0.015	0.02	0	N12
B	0.055	0.05	0	N10
G	0.035	0.035	0	N11

7.2 Characteristic of the mesh

Many nodes: 21

Number of meshes and types: 8 PENTA6 + 8 TRIA3 + 16 QUAD4

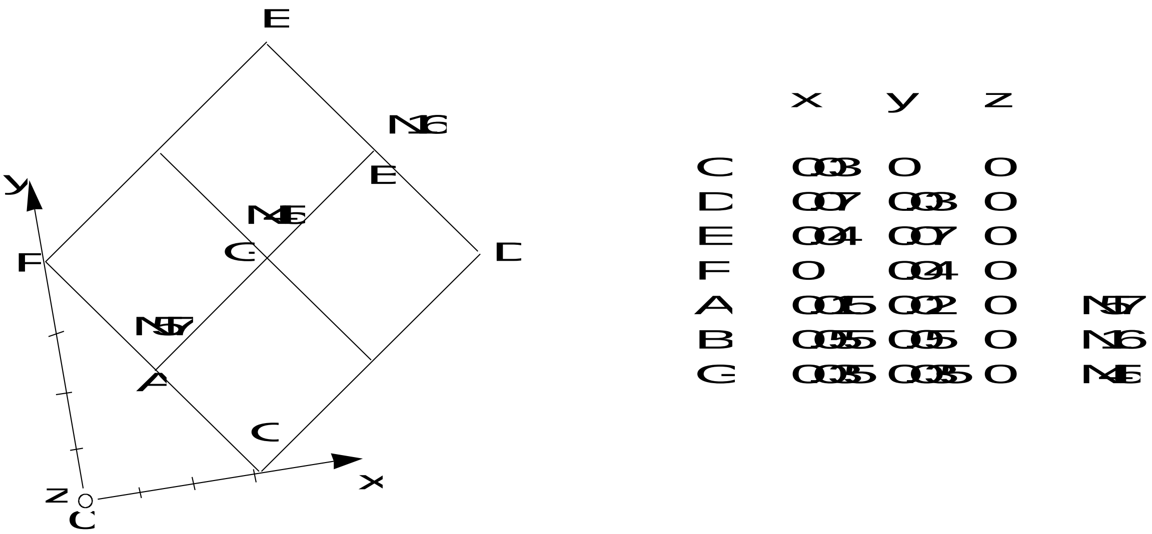
7.3 Values tested

Identification	Reference
$T(A)°C$	100.
$T(B)°C$	20.
$T(G)°C$	60.
$\vec{\varphi}(m).\vec{i}\ (\forall m)\ W/m^2$	960.
$\vec{\varphi}(m).\vec{j}\ (\forall m)\ W/m^2$	720.

8 Modelization F

8.1 Characteristic of the Voluminal

modelization (HEXA20)



8.2 Characteristic of the mesh

Many nodes: 59

Number of meshes and types: 4 HEXA20 + 20 QUAD8

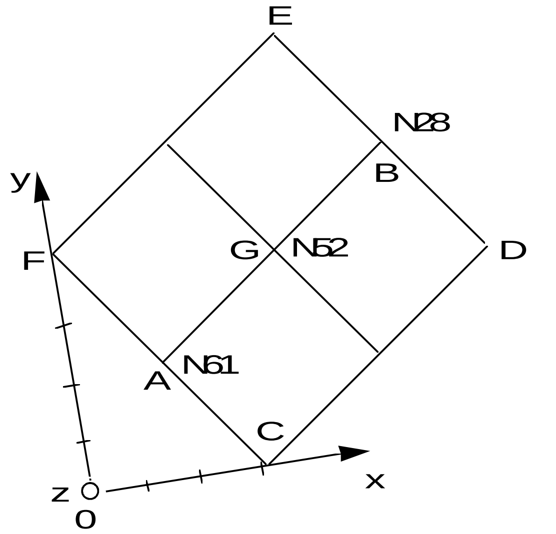
8.3 Values tested

Identification	Reference
$T(A)°C$	100.
$T(B)°C$	20.
$T(G)°C$	60.
$\vec{\varphi}(m).\vec{i}\ (\forall m)\ W/m^2$	960.
$\vec{\varphi}(m).\vec{j}\ (\forall m)\ W/m^2$	720.

9 Modelization G

9.1 Characteristic of the Voluminal

modelization (PENTA15)



	x	y	z	
C	0.03	0	0	
D	0.07	0.03	0	
E	0.04	0.07	0	
F	0	0.04	0	
A	0.015	0.02	0	N61
B	0.055	0.05	0	N28
G	0.035	0.035	0	N52

9.2 Characteristic of the mesh

Many nodes: 65

Number of meshes and types: 8 PENTA15 + 8 TRIA6 + 16 QUAD8

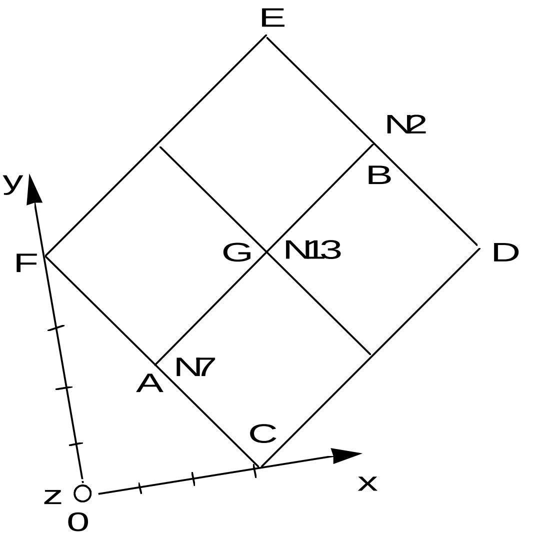
9.3 Values tested

Identification	Reference
$T(A)°C$	100.
$T(B)°C$	20.
$T(G)°C$	60.
$\vec{\varphi}(m).\vec{i}\ (\forall m)\ W/m^2$	960.
$\vec{\varphi}(m).\vec{j}\ (\forall m)\ W/m^2$	720.

10 Modelization H

10.1 Characteristic of the Voluminal

modelization (TETRA4)



	x	y	z	
C	0.03	0	0	
D	0.07	0.03	0	
E	0.04	0.07	0	
F	0	0.04	0	
A	0.015	0.02	0	N7
B	0.055	0.05	0	N2
G	0.035	0.035	0	N13

10.2 Characteristic of the mesh

Many nodes: 18

Number of meshes and types: 20 TETRA4 + 6 TRIA3 + 16 QUAD8

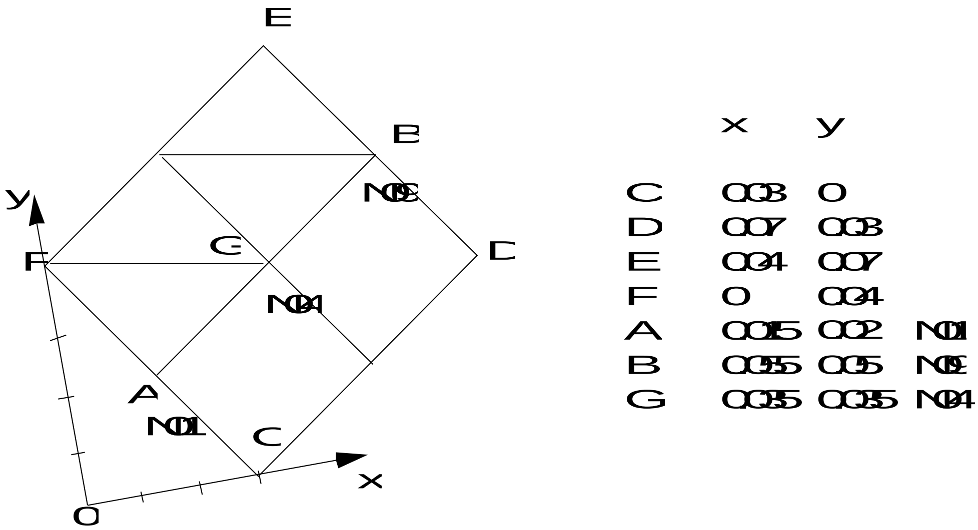
10.3 Values tested

Identification	Reference
$T(A)°C$	100.
$T(B)°C$	20.
$T(G)°C$	60.
$\vec{\varphi}(m).\vec{i}\ (\forall m)\ W/m^2$	960.
$\vec{\varphi}(m).\vec{j}\ (\forall m)\ W/m^2$	720.

11 Modelization I

11.1 Characteristic of the Voluminal

modelization (TETRA10)



11.2 Characteristic of the mesh

Many nodes: 125

Number of meshes and types: 48 TETRA10 + 16 TRIA6

11.3 Values tested

Identification	Reference
$T(A)°C$	100.
$T(B)°C$	20.
$T(G)°C$	60.
$\vec{\varphi}(m).\vec{i}\ (\forall m)\ W/m^2$	960.
$\vec{\varphi}(m).\vec{j}\ (\forall m)\ W/m^2$	720.

12 Modelization J

12.1 Characteristic of the modelization

It acts of a case functional test and data-processing NON-regression of computation of the error indicator established a posteriori in thermal (cf [R4.10.03]). He exhumes a cartography of spatial error on which will be based, in a loop Python, tools of refinement/coarsening HOMARD encapsulated in `MACR_ADAP_MAIL` (cf [U7.03.01]).
The computation of this card of error indicator is carried out, via option "`ERTH_ELEM`" of the operator of postprocessing `CALC_ERREUR`, on `an EVOL_THER` (provides RESULTAT `to the key word)` coming from a former thermal computation (linear or not, transient or steady, isotropic or orthotropic, via `THER_LINEAIRE` or `THER_NON_LINE`, cf environment necessary, parameter setting and perimeter of use [R4.10.03] §6.2/4).
This computation requires as a preliminary the recourse to option "`FLUX_ELNO`" of `CALC_CHAMP` which determines the values of the vector heat flux to the nodes (cf example of use [R4.10.03] §6.5).
The indicator consists of fifteen components per element and for a given time. In this case test, one calculates the fifteen components but the procedure of refinement/coarsening is pressed only on the component `ERTABS` which represents the absolute total spatial error (cf [R4.10.03] §6.3).
In order to be able post-to treat via `POST_RELEVE` or GIBI, one needs to extrapolate fields by element in fields at nodes by element. The addition of option "`ERTH_ELNO_ELEM`" (after the call to "`ERTH_ELEM_TEMP`") makes it possible to carry out this purely data-processing transformation. For one time and a given finite element, it does nothing but duplicate the fifteen components of the indicator on each node of the element.
This modelization thus constitutes as much an example of use, in a loop PYTHON, couplings "computation of indicator"/"refinement/coarsening of mesh" possible, that a case test of NON-regression of options "`ERTH_ELEM_TEMP`" and "`ERTH_ELNO_ELEM`" and of their dependancy with the process of mending of meshes.
This case test I takes again the characteristics of the modelization and its mesh (`TETRA10` + `TRIA6`) associated.

12.2 Values tested

One tests the data-processing NON-regression of component ERTREL (relative total spatial error) of the error indicator compared to the V6.2.1 versions of platforms SGI and SUN of *Code_Aster* and of the V4.3 version of the software HOMARD. The relative tolerance is thus severe: 5.10-$^{6\%}$.

Identification	***Aster***	**Tolerance**
Value of `ERTREL` on mesh `MA1` before mending of meshes	4.15918735 10-5	5.10-8
Value of `ERTREL` on node `NO4` before mending of meshes	4.15918735 10-5	5.10-8
Value of `ERTREL` on the M1 `mesh` after mending of meshes	5.48408914 10-6	5.10-7

13 Summary of the results

the field solution (linear) belongs to the space of interpolation of all the elements tested. The results are thus naturally excellent.