2.5 Post teeth

INTRODUCTION

We have defined, in one of the previous specifications (1984), a crown on a premolar. It supposes the existence of a tooth in a relatively good state so that the practioner can find enough matter to get a solid and important stump. In the presence of a depulped tooth, maybe even destroyed, he will have to constitute the coronary part for it to serve as base to the future crown or the future bridge. We call fake stump a reconstitution coronnoradicular. It is a prosthetic piece with essentially radicular anchoring compensating the tissue loss and giving to a tooth a good resistance (figure 54). This prosthesis imposes itself if the classic methods of reconstitution aren't enough. They represent a non negligible activity of dental surgery (about 60% of reconstitutions) and must thus be solved in CAD as quick as possible. This here specifications book comes directly from those written for the crown. A certain number of chapters are thought to be acquired.

2.5-1 Odontological criteria for restoration

2.5-1.1 Restoration criteria

The dentist must respect a certain number of criteria which are:

2.5-1.1.1 Endodontic conditions

He must estimate whether the restoration of the root is correct. It will only be interesting in CAD after the development of the digital x-ray (programme being studied). At the moment, this operation is done manually with a retro-alveolar film.

2.5-1.1.2 Morphologic considerations (figure 54)

It is about doing the correct radicular preparation which is not too damageable in order not to weaken the root. The only elements to know for a CAD creation are:

- the rapport length of the post with regards to the total length
- the rapport diameter of the post with regards to the diameter of the preparation
- the angular orientation of the post with regards to the axis of the canal part.

2.5-1.1.3 Mechanical considerations (figure 54)

It is about having data on the retention value. This data is brought by different values and only represent little calculation: they are particularly the estimation of the contact surface (stump) with regards to the post's surface and the height of the post with regards to the height of the fake stump brought back to the finishing line (average value + or -).

2.5-1.1.4 Electro-chemical considerations

Not important for us given the used material.

2.5-1.2 Different clinical types

2.5-1.2.1 Monoradicules

We have several possibilities defined essentially by the position of the separation line between the fake stump and the tooth itself:

- either the fake stump will be entirely covered by the dressing (crown). In this case, the dento-prosthetic joint will be insured by the crown and the manufacturing will be cone shaped
- either the fake stump insures the dento-prosthetic joint. We must manufacture as well a shoulderin
- or the case is mixed and we will have to respect each zone (see further)

2.5-1.2.2 Pluriradicules

If the posts are parallel, we will be in the previous case but if the stumps are divergent, we will have to offer different solutions.

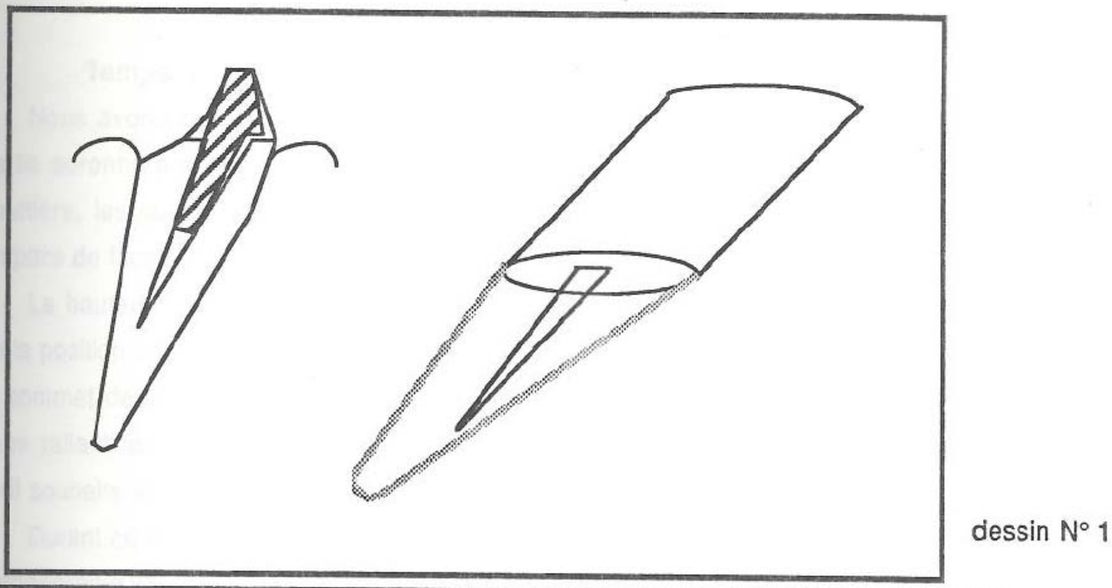
2.5-2 Coronnoradicular restoration in CAD

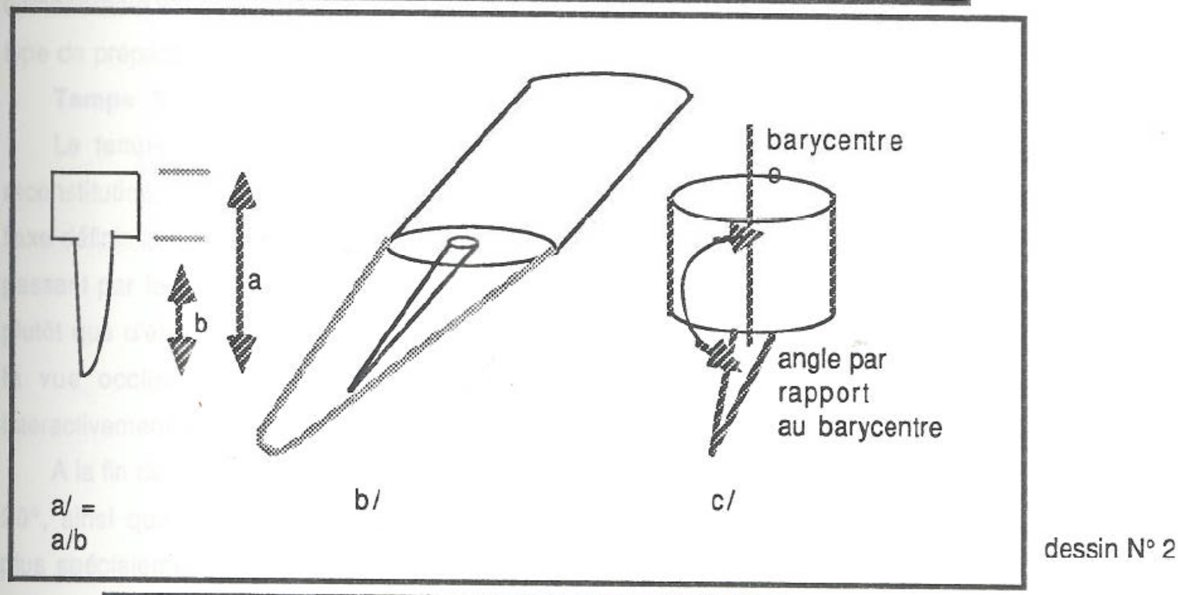
2.5-2.1 Total restoration

After the cut, the dentist will be confronted with a type of plateau with the post's hole. We know that it is impossible to do the impression of the post hole (figure 55). For this reason, a specific protocol of 4 steps has been devised.

Step 1

We do one (or 2) impression(s) of the fake stump with the post in place, cut at the desired height. We get the environment, the plateau (figure 55) and the post's axis. The practioner will have to trace the finishing line of this coronnoradicular restoration and indicate which clinical type is used. Also, it does the same verification as for the crown (see previously).





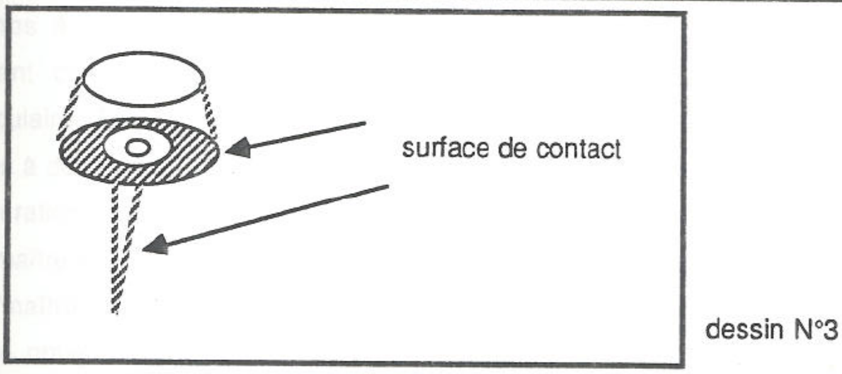


Figure 54

LE PIVOT, CRITERES DE RECONSTITUTION

Step 2

We have defined a certain number of elements which will enable us to build the coronnoradicular part of our fake stump. These elements are for example the gutter line, the cusps or the occlusion plan. The superior part of the cone will be place in the space in order to integrate harmoniously with these elements.

The height of this plateau (the top part) will have a z position directly deduced from the position of the antagonist teeth's surfaces. It will be at 1.5mm of a plan going through the top of the lowest cusp, a value which is interactively changeable and never lower than the line linking the contact points. The dentist keeps the possibility of defining the distance he wants to have between the plateau and the antagonist teeth.

During this second step we have defined the height of the stump of the coronnoradicular restoration when in the first step we had traced a finishing line as well as the type of restoration (with or without shouldering).

Step 3

The third step has the function of defining the exact position of the vertical wall of the restoration. The occlusal view enables us to know the virtual plan in x y going through the axis defining the height in z of the fake stump. We lower a perpendicular to this plan going through the centre of gravity of the left surface defined by the finishing line. Then, and instead of raising un cylinder from the plateau's surface to the superior plan (at the occlusal view plan), we raise a cone whose inclination varies from 5° to 20°, interactively chosen and depending on the frame.

At the end of the third step, we have the cervical limit of the fake stump, with slopes of 5 to 20° as well as 2 superior and inferior plateaus. All there is left to define is the radicular post, more specifically its intra-canal part.

Step 4

During this step, the length of the intro-coronnary post, intra-radicular, will be determined. For that we have taken care (figure 57) of memorising several posts identical to the standard posts present in a practioner's case.

The operation is as follows: we drill normally the canal and place one of the three "master model" posts corresponding to the 3 volumes known by the computer. At the top of these "master model" posts is an asymmetrical pyramid enabling the knowledge, in optical impression, of the spatial position of this pivot. Moreover, a graduation has been placed in the tooth, enabling the estimation of the post's length inside the canal hole. The post is placed in the tooth, the "pyramid" side emerging from the tooth. An impression is captured and enables the estimation of the part emerging from the canal and its orientation in the coronnoradicular restoration.

The software knowing the volume of the fake stump, the length of the emerging post and the position of the graduations, it will tell the dentist where to cut, no the master model pivot but an identical pivot with new materials. It will serve as definitive pivot.

Step 5

The chosen radicular post is cut where indicated by the computer. The fake stump is manufactured and a drill drills an axis corresponding to the emerging part of the post. The dentist has to glue the 2 pieces together. If the posts are divergent, the fake stump will be completely pierced (sliding post).

CONCLUSION:

The practioner's work for a post tooth is simple and is limited to:

- tracing the finishing line with the clinical type indication such as for a crown (3 possible cases to tick)
- possibly modifying the frame's angle for the fake stump
- cutting the post where indicated by the software
- indicating the existence or not of a shouldering and giving the value (250-500-750µ) par frame. This shouldering will be done parallel to the finishing line at a height interactively defined by CAD.

2.5-2.2 Partial restoration

It is done in an identical manner without taking into account the existence of a shouldering.

2.5-2.3 Mixed restoration

It supposes the existence on the tooth of a part of the shouldering. We trace the finishing line, interactively, we raise the cone as if there were no shouldering (automatic) then we trace interactively the limit of the shouldering by giving the desired value, which has for effect to reduce the size of the fake stump and to create a shouldering. The reduction must be homothetic.

2.5-3 Interactive deformations

We find the same deformations as we had for the crown with more possibility of simply playing on the angle of the fake stump and the depth of the post. This deformation happens on one point only and one view only (X_Y) horizontally.

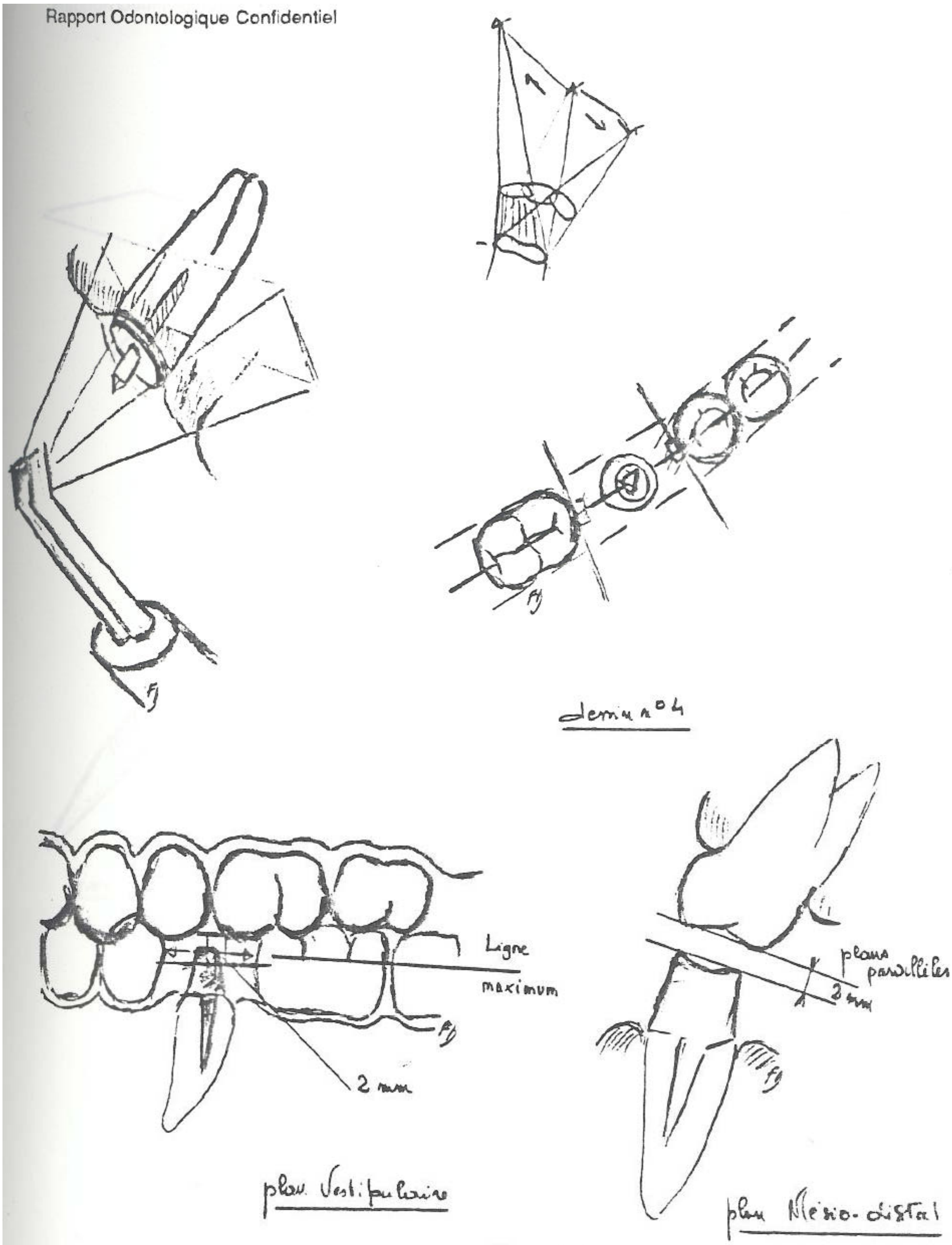


Figure 55

PREPARATION DES TENONS

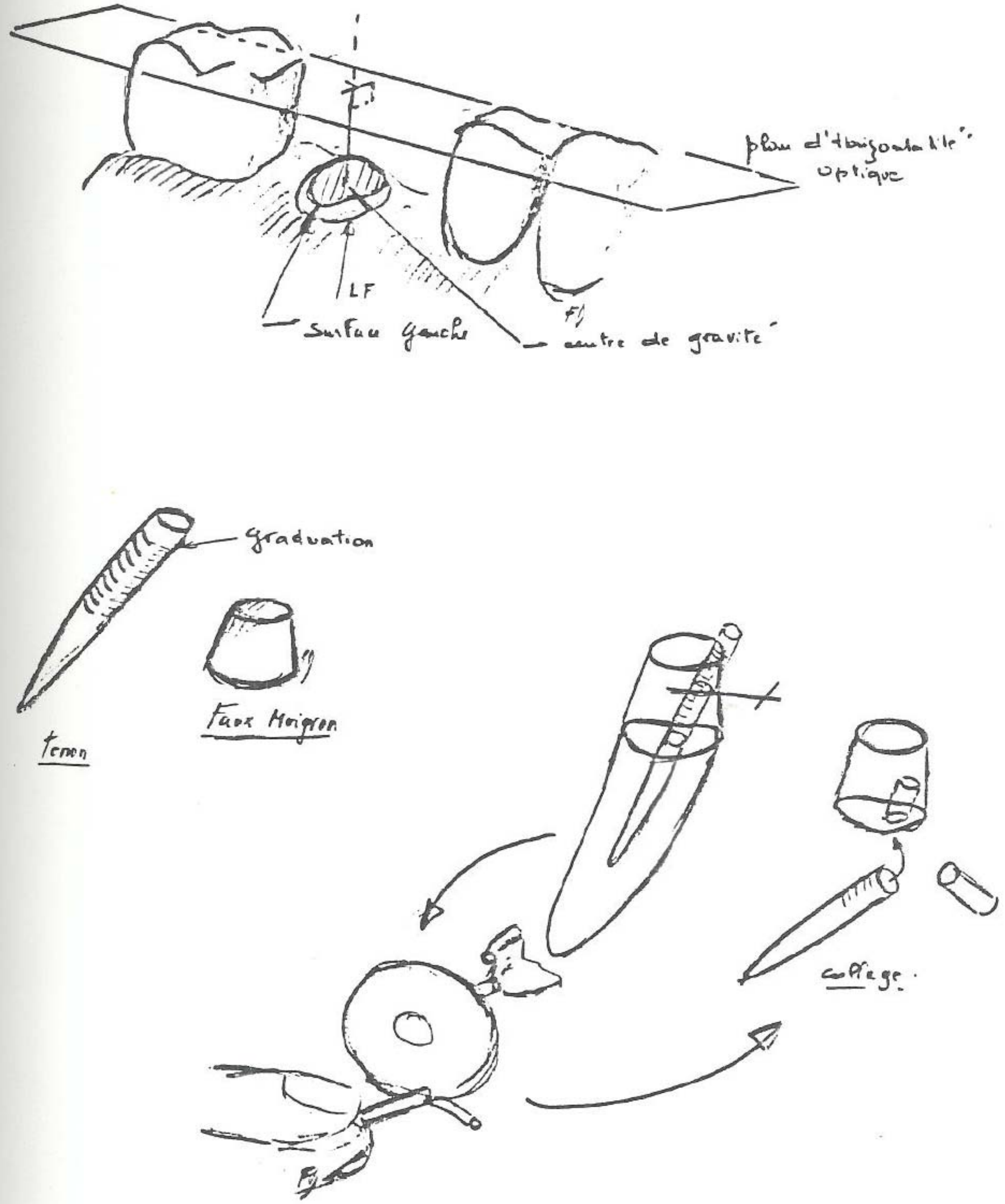


Figure 56
LE FAUX MOIGNON

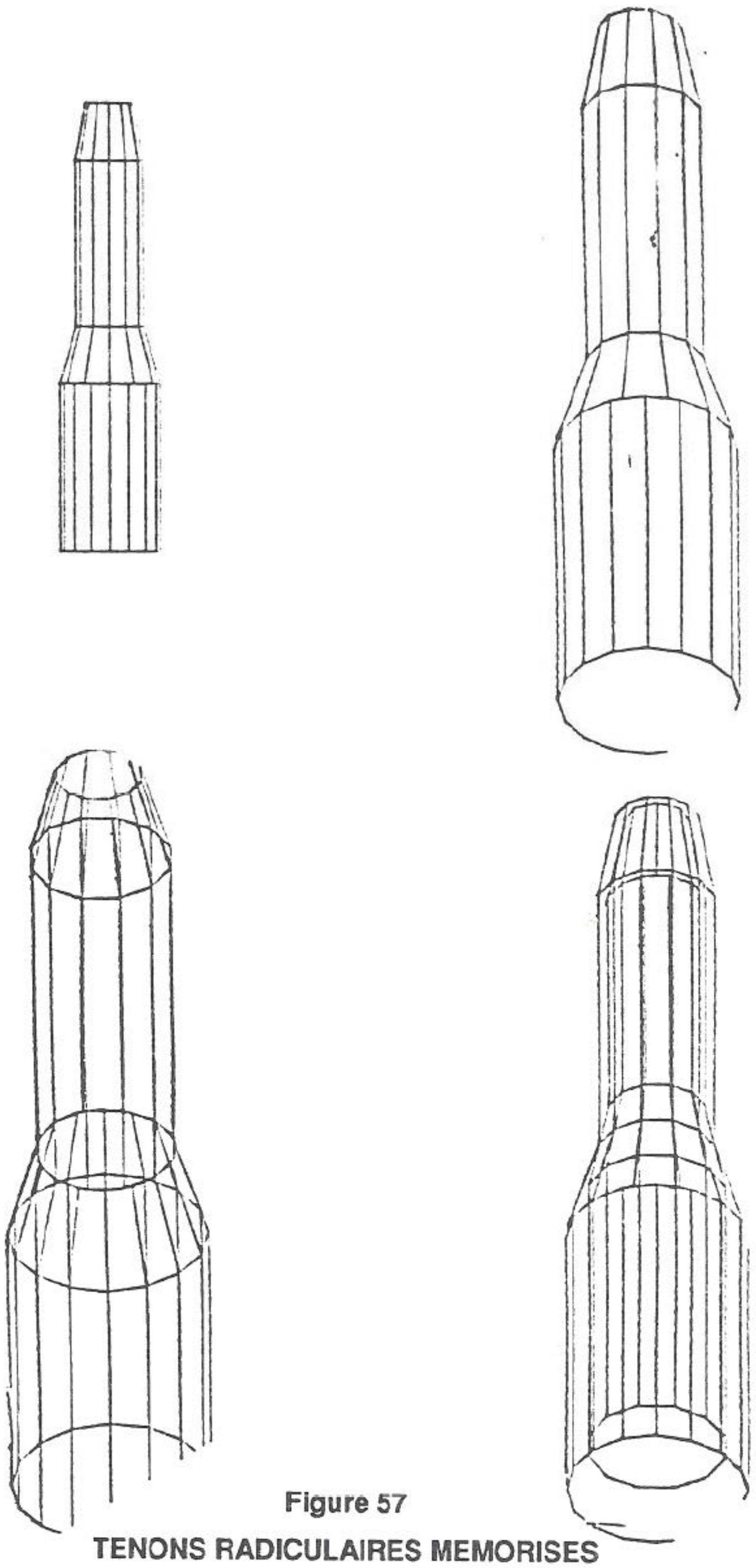


Figure 57

TENONS RADICULAIRES MEMORISES

2.6 Inlays and onlays

Numerous studies have been made on the fabrication of inlays in CAD/CAM. Aware of the effectiveness of this computer methodology in this domain, the first researches in the USA (Swindon) as in France (Duret) (figure 58), have led on the realisation of this type of restoration. We won't come back on the multitude of work between 1973 and 1987. We will simply cite the MORMANN and BRANDESTINI projects in Zurich (Quintessence Heft 3, March 1987, Ref. 6962) and the realisation of a device to manufacture inlays. As it appeared certain that the reader may confuse dental CAD/CAM and a simple reproduction tool machine as the one in Zurich, we wanted to remind the differences between both systems, the Zurich one and the Vienne one (HENNSON). These differences are found:

- at the impression level: with the MÖRMANN system, it is impossible of capturing more than one impression, which obliges us to use large cavities and no counter-remains. This restriction, forbids any use of the crown, bridge and other fixed prosthesis process. It isn't a little restriction when we know it takes more time to master the correlation than to do a tri dimensional reading. Moreover, the precision of the material stays to be demonstrated if we refer to articles published by this author.
- At the data treatment level: it appears that the software can't define automatically bumps and holes, an operation which is rather complex which obliges the dentist to trace inferior and superior limits of its preparation in the Zurich system.
- With the Swiss device there is no intervention of CAD, which stops the creation of space for cement and the modelling of the occlusal surface.
- The MÖRMANN manufacturing only happens in 2D1/2 with only 2 discs (today).
- No study of material or coloration has been done.

We understand that no comparison is possible between both systems (fifugre 59 and 60).

2.6-1 Theoretic principles

The realisation principle of the inlay joins the crown's principle. The difference being that the intrados, instead of being interior will be exterior and the manufacturing of the extrados will be limited to the worked zone and proposed by the dentist. Two protocols can be followed.

2.6-1.1 Protocol 1

It is directly issued from working on the crown. The practioner has limited, with the image treatment, the finishing line which corresponds to the superior part of the modelling (limited with bevel)

The principle consists of:

2.6-1.1.1 Applying the theoretical tooth corresponding to the prepared tooth

2.6-1.1.2 Making the cusps and furrows correspond of the theoretical tooth to the real tooth previously modelled in spider's web and of which we have extracted the characteristic lines. We won't take into account the possible microscopic differences of the surface but we will respect the cusp angle and the furrows line of the tooth modelled in spider's web if it is powerful and of the theoretical tooth is the Inlay/Onlay is important.

Note: The placement in environment must be based on the recognition of the cusps (peek) and the peek line, if the finishing line is occlusal, that is to say if we have a single-face inlay. However, it must be based on the greatest contour line on the vestibular and lingual faces in the case of big inlays or onlays as they are rarely worked on. The furrow can be used following the indication of the impression capture, before the cut (better) or after. The study of the isoplans and particularly an affinity effect between the isoplan of the theoretical tooth and the real tooth will enable a good adjustment of the elements.

2.6-1.1.3 Everything that is limited by the finishing line corresponds to the piece to be manufactured. We separate the extrados (portion of surface of the theoretical tooth) and the intrados in the shape of male or mixed male and female. The intrados will have similar contraction to the dilatation of the intrados of the crown but in negative value.

2.6-1.1.4 The manufacturing corresponds to the cut part of the theoretical tooth for the extrados and to the impression, the part closed by the finishing line for the intrados.

2.6-1.2 Protocol 2

The principle is to use a double impression of the same object by using correlation references described in protocol 1 (isoplan).

2.6-1.2.1 The practioner positions his marking points et reconstitutes the tooth with wax. We do an impression of the reconstituted theoretical tooth précising the finishing line (limit of the wax).

2.6-1.2.2 We prepare the cavity and indicate the finishing line on the second impression.

2.6-1.2.3 We do a mathematical difference between the first and second impression to get the piece.

2.6-1.2.4 We contract the internal part (corresponding to the second impression) for the space for the cement.

CONCLUSION

Two methods of handling extremely simple, the practioner can be contented with tracing the finishing line and the rest is automatic. A final impression enables him to apply the corrections already described for the crown, interactively.

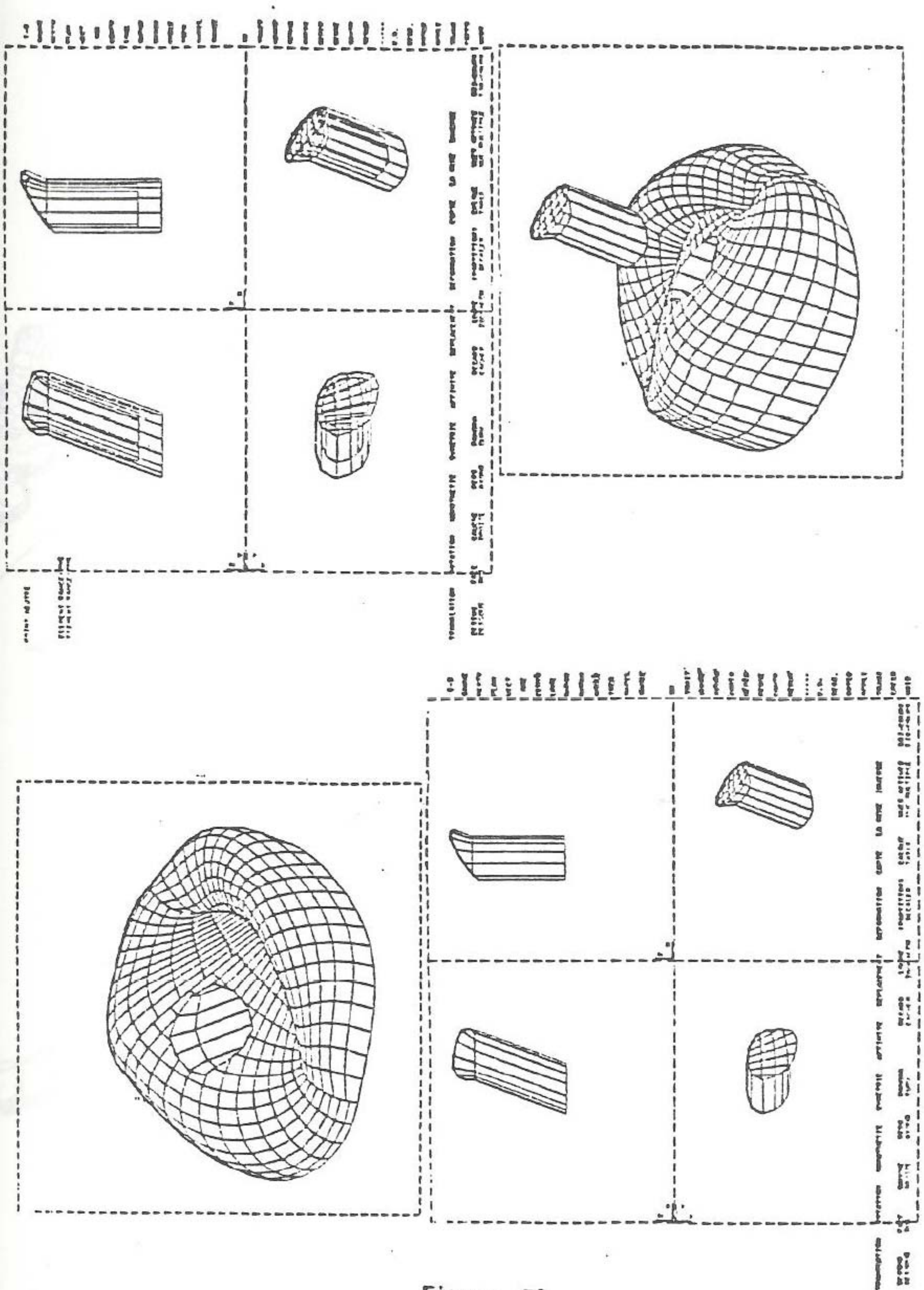


Figure 58

INLAY EN 1982

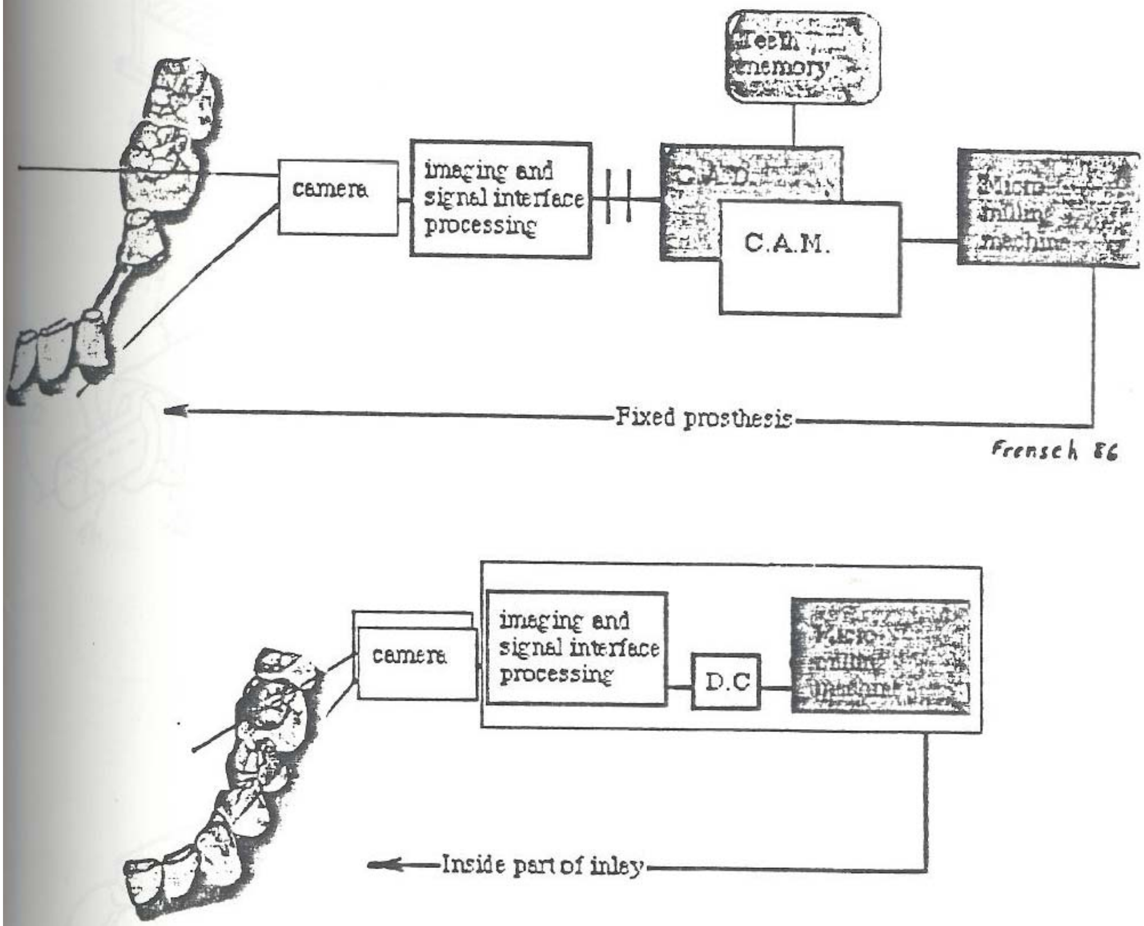

Teeth memory
camera
imaging and signal interface processing
C.A.D.
C.A.M.
Micro milling machine
Fixed prosthesis
Frensch 86
camera
imaging and signal interface processing
D.C
Inside part of inlay

Figure 59

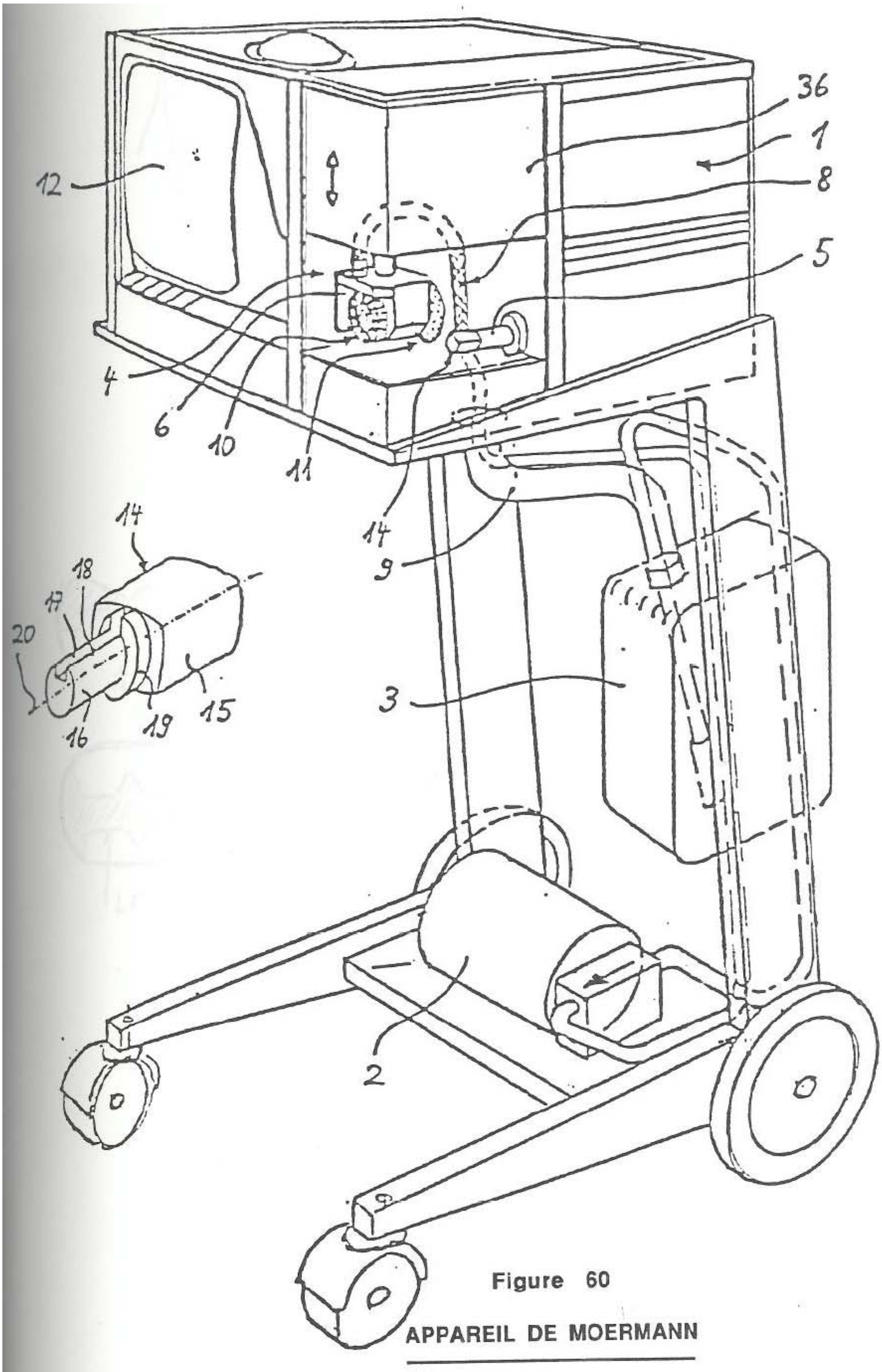


Figure 60

APPAREIL DE MOERMANN

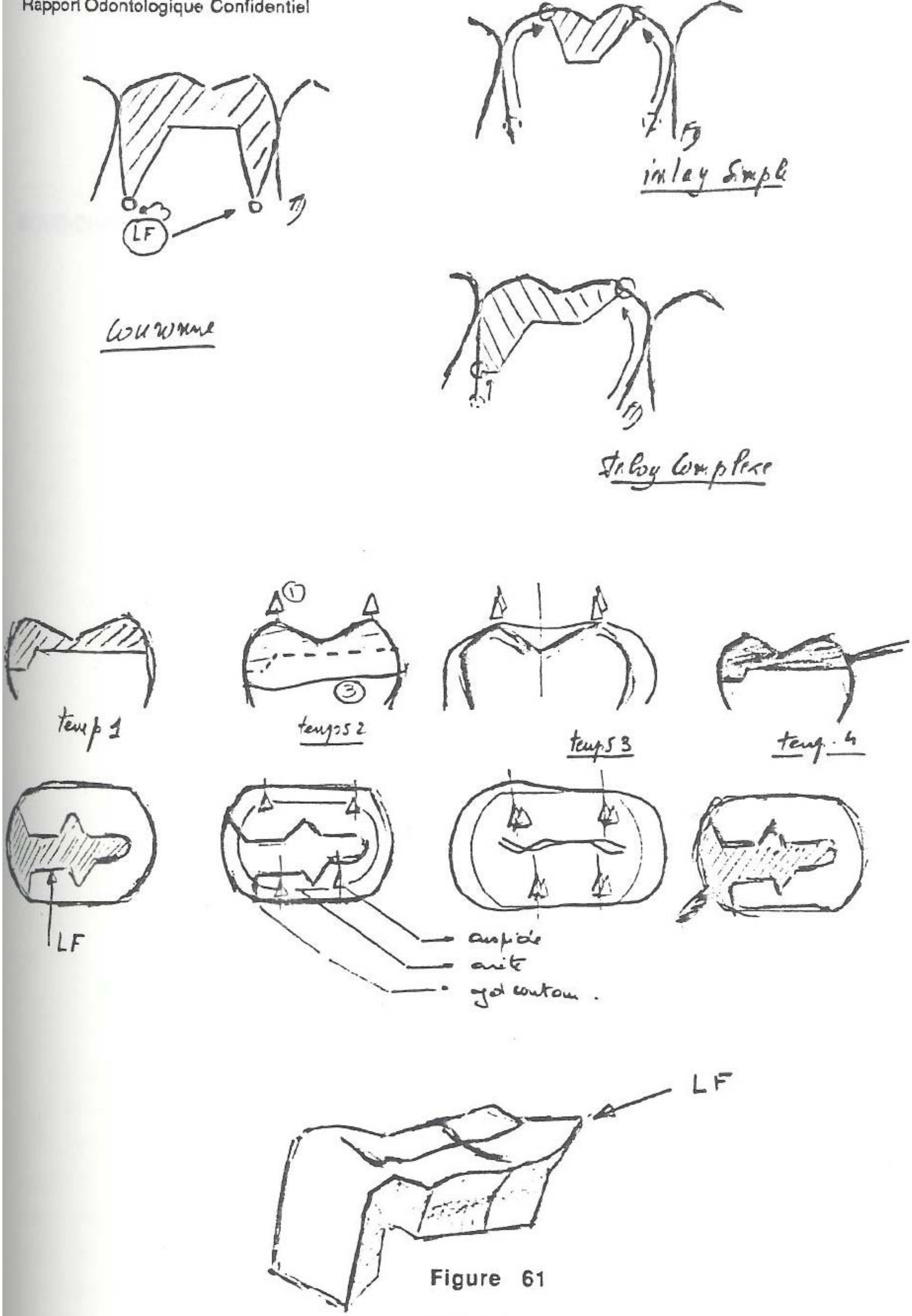


Figure 61

LES INLAYS

2.7 Attachments

The preparation mode of the attachments stays extremely simple if we admit the great basic theoretical principle announced in 1982 and which presents a respect of all the work previous to our research.

There are numerous publications on attachments. Let's signal in particular:

- DOUCET, ICBI, 210 pages, 1973
- PREISKEL, CDP, 315 pages, 1985

We won't come back on the automatic determination of place trace described in our Patents (1982) and in other articles as the recent part by Santoni et Coll (Industrie Dentaire, p47-50, 1986). They are part of an ulterior development easily integratable to our technology. It is important to define the rules of manufacturing to enable the insertion of attachments or the glueing of hooks on prostheses done by CAD/CAM. We proceed by following the rules of the excellent article by D. SEPULCRE and J. MIGOZZI in QQS, 8, p85-93, 1983. Two types of preparation must be envisaged:

- preparations by wedging and retention
- preparations insuring the fixation of attachments

2.7-1 Preparation of wedging and retention

All the prosthetic fixed elements have been studied and adapted in cAD/CAM, being unitary crowns or bridges, as we have previously described. If the CAD computer knows exactly the morphology of each prosthesis, the practioner knows where to position each of these elements necessary to the good stability of the mobile prosthesis. This determination will be manual as long as the automatic plaque determination software isn't precise enough.

2.7-1.1 Preparation of wedging (figure 60)

The practioner indicates which tooth will be used for the wedging. The wedging is present as a light flat suppressing the lingual bump destined to receive the wedge's arm of the removable prosthesis' hook. The drilling must be on the lingual face, respecting the contact zone and being maximum at 1/3 cervical of the crown. It is a drilling in 2D ½ with a large vacation (1mm), inclined at 130° or 90°. The thickness mustn't be over 2/3 of the thinnest part. In CAD/CAM, it consists of doing a bolean subtraction with a cylindrical tool, turning the lingual face of the indicated tooth. The dentist chooses:

- the beginning and the end of the trace (the line of the tool will be automatically traced)
- the tooth in question

The manufacturing axis will be a function of the chosen insertion axis. It will be common to the whole elements having the same treatment. It must be the same axis for any preparation by wedging. Without data, we apply a perpendicular movement to the average plan defined by the greatest contour line of the teeth supporting the wedging.

2.7-1.2 Preparation of retention (hooks and non prefabricated attachments)

There are several shapes of drilling to do. The function is very simple for CAD/CAM with the exception of the fact of the 100° inclination.

We can find 4 types of preparation to do at the contact zone level, on both sides of this zone and according to the vertical axis previously defined.

2.7-1.2.1 Wells (figure 62)

Vertical walls whose height is more important that the width (height and friction insure the retention of the piece). Retention is not the result of the right angle, a cylindrical drill with a 2D movement can be enough. For the bottom, we use a little cylindrical drill. The thickness, that is to say the width of the little stall, will depend on the width known by CAD at this point, of the crown between the intrados and the exterior shape. In no case it will be over 2/3s of the crown's width at the thinnest point (see SEPULCRE drawing). The practioner, using this work, will address CAD problems with wells to the technician realising the mobile plate and setting the temporary bridge (use of traditional impression).

2.7-1.2.2 Clips

They are important retentive elements completing the action of the hook. They are semi spherical, spherical or oval depressions situated on the proximal faces of the crowns or bridges. Not very deep, 1 to 2 mm, (specified interactively by the dentist), (the manufacturing movement and the drilling are identical to the wells by not as low).

2.7-1.2.3 Equipoise hooks

There are the wells associated to a wedging on the lingual face of the dent. All you need to do is combine the two manufacturing previously described.

2.7-1.2.4 THOMPSON attachments (figure 63)

Placed on the distal face, it is a well (see 2.7-1.2.1) but it has no mesio-distal retention perpendicular to the axis of the peek (parallel to the distal plan of the supporting teeth).

2.7-2 Preparation of attachments supports (figures 64 and 65)

It is about preparing the placement of the prefabricated attachment. Two possible cases can appear: either we manufacture the piece of the preparation defined by the laboratories (long and complex) or we impose to the laboratories an intermediary piece (long to get).

The estimation of the thickness of the prefabricated slide enables us, depending on the thickness of the cap, to choose a precise type of attachment. On each case, with the exception of soldered attachments, we must prepare a well as previously described. There are:

2.7-2.1 Rigid conjunctor

We must dig a larger well to place the slide corresponding to the type of attachment. We can find rigid conjunctors which are slides, braced or CSP systems.

We advance slowly with the study of the manufacturing of these little stalls as they are specific to each conjunctor. It will depend on the good will of the manufacturers as CAD manufacturing is simple (2D1/2 manufacturing) in every case, as the tool machine is the best parallelisor there is.

2.7-2.2 Articulated conjunctor

Same remarks as previously

2.7-2.3 Articulated bracing

We must manufacture a counter piece on which is welded the male part of the conjunctor. Simple even though a very precise study must be led.

The bars are for example placed with a slide glued in the wells (refer to the manufacturing of wells).

2.7-2.4 Strength distributor

For some we will need manufacturing of complementary wells and sealings and for others, wedging (external males).

2.7-2.5 Horizontal retentive units

Same remark

2.7-3 Conclusion

Even if today no study has been led on attachments, we know that the work isn't a major difficulty. Let's summarise the principle. The tooth which supports this very particular prosthesis is perfectly known by the software in its morphology and also its orientation. The preparation of an attachment in CAD is really only the determination of the 2D manufacturing, sometimes 2D1/2, of a reception site and only touches three faces. The tooth will be conceived as described in the crown and bridge chapter and will over-manufactured by one or some specific tools according to an axis which is the insertion axis of the mobile prosthesis.

We won't discuss here the insertion axis. It will be the object of a particular chapter but apparently, we can consider that this manufacturing will be in the perpendicular axis of the projected plan of the greatest contour line. Seeing as there are several attachments, this axis will be an average. The digging, that is to say the depth inside the crown in the proximal sense, will be defined at 2/3rd of the thickness (but it can be different after the specification of the material). Its position will be developed in a software of specific study on the plates' contour. Finally, to answer to numerous cases, a specific study of welcome site for each attachment and a glue will be created to replace weldings.

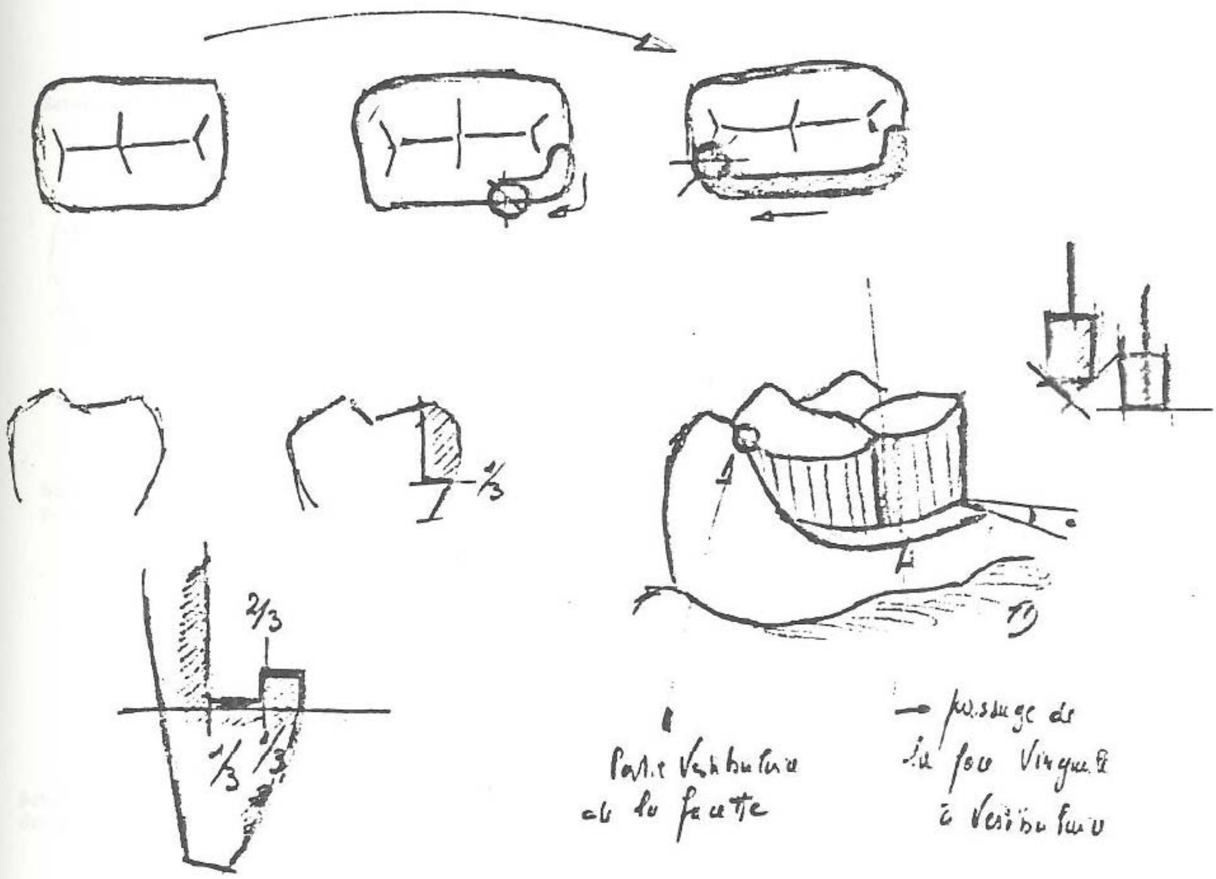


Figure 62

LES ATTACHEMENTS

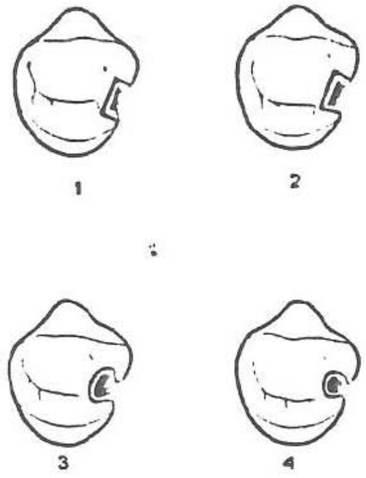
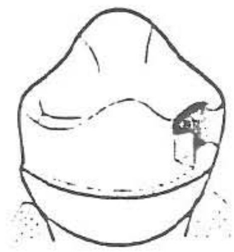


Schéma · Vue occlusale des différents puits.



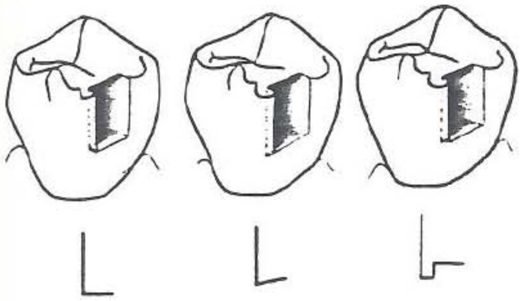


Schéma Les différentes formes du plancher des puits.

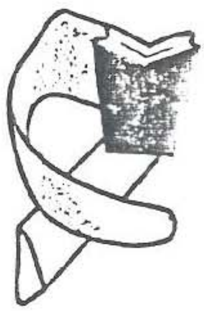


Schéma Le crochet Equipoise.

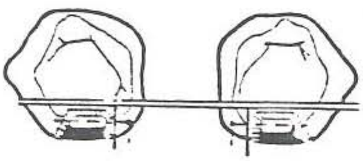


Schéma 9. L'attachement de Thompson. Vue occlusale des glissières.

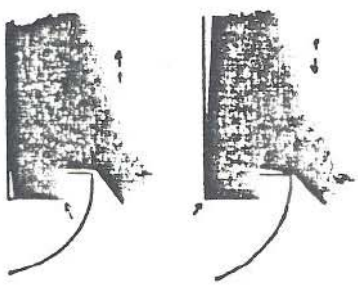


Schéma Rotation de la partie mâle dans la glissière de l'attachement sous l'effet d'une force occlusale.

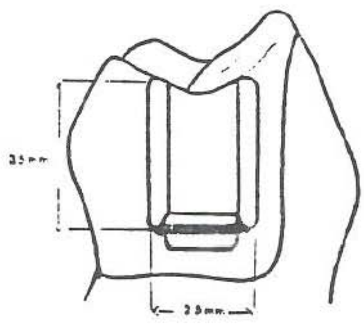


Schéma Vue proximale de la glissière.

Figure 63

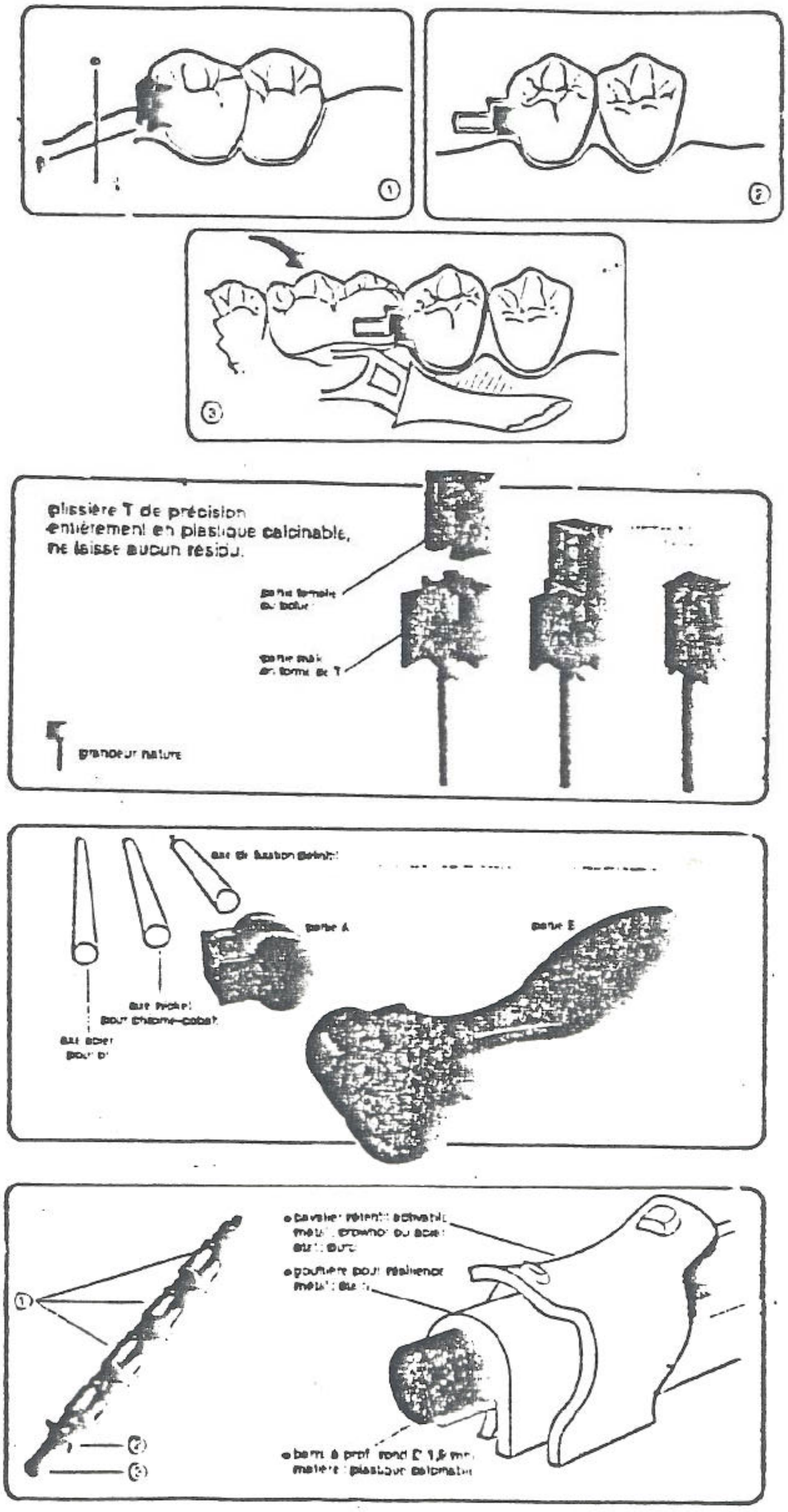

plissière T de précision
entièrement en plastique calcinable,
ne laisse aucun résidu.
grandeur nature

Figure 64

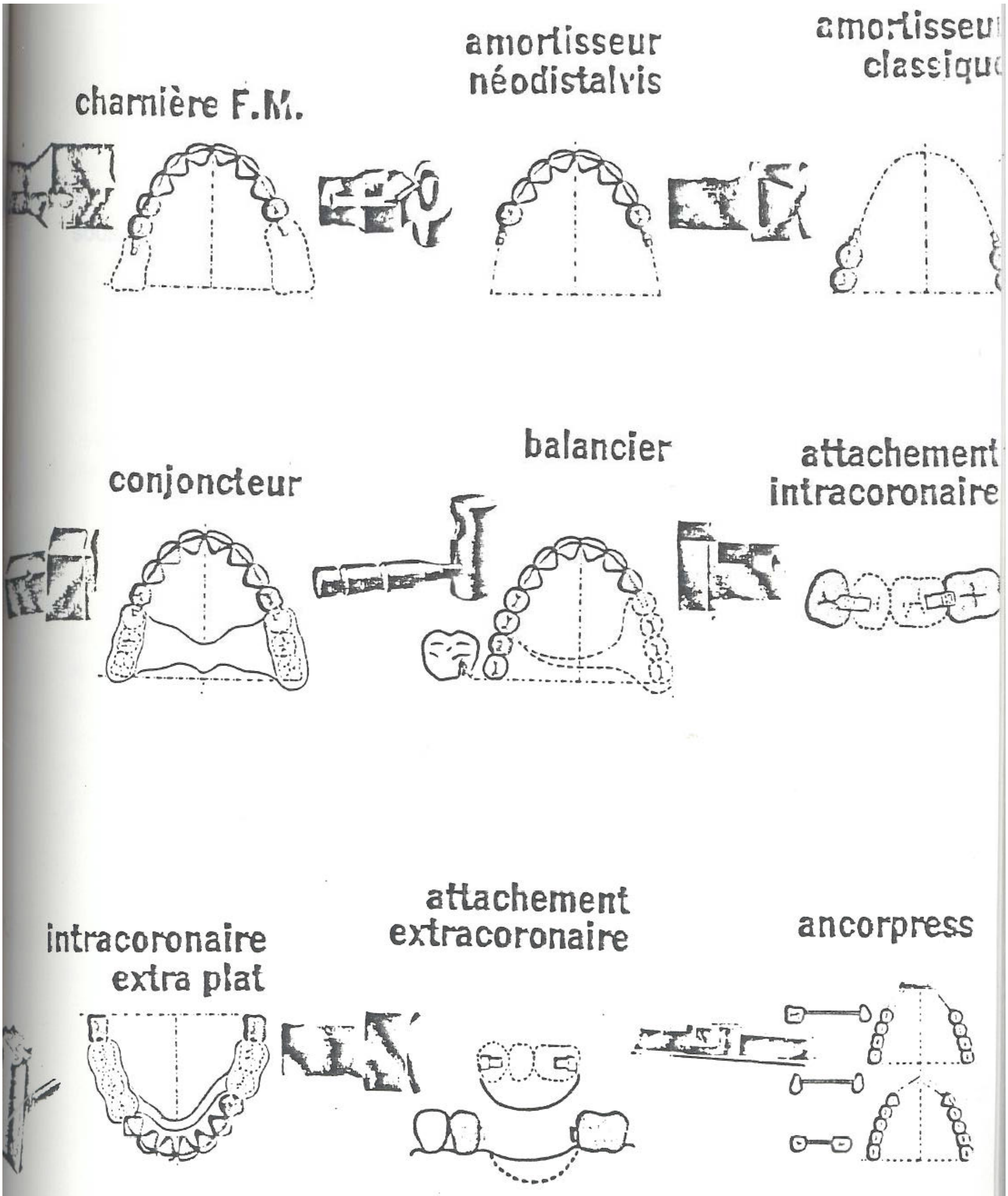

charnière F.M.
amortisseur
néodistalvis
amortisseu
classiqu
conjoncteur
balancier
attachement
intracoronaire
intracoronaire
extra plat
attachement
extracoronaire
ancorpress

Figure 65

2.8 Orthodontics

Orthodontics, as Parodontology, is a complex science necessitating an extremely thorough analysis for diagnosis. It isn't HENNSON's work to redo what already exists but to use the competence of each specialist. There is today a certain number of very performing softwares around the world which can enable a complex and detailed analysis in each case. The ambition of HENNSON is to adapt these softwares to the Cad materials. From the diagnosis done by the software, the CAD/CAM executes orthodontic prostheses in accordance with the proposition of the therapeutics.

What is most flagrant is the apparent complexity for the dentist of the mastering of the tri dimensional movement of a tooth in a buccal space. Outside the mobile apparels which disappear more and more, the orthodontist uses brackets, where the forces are applied, to transmit a movement to the tooth depending on the wished direction. For that, he has two alternatives:

- torque the wire and place it in a narrow gorge
- place a "straight" wire in "pre-torqued" gorge

There is no question of CAD/CAM substituting to the first method as, on the one hand it is extremely complex for the generalist and on the other, the price of a bracket , even aesthetic, is to low to make CAD/CAM competitive. The straight wire technique is far more interesting. In this case, a non torqued wire is forced into a gorge which by its angulation, will get back to the alignment of the straight wire. The bracket being fixed to the tooth, it's the tooth that will move. RICKETTS, who is at the origin of this concept, opens all the big doors of orthodontics to CAD/CAM. If we know:

- the bone resistance
- the value of the pressure from the elasticity of the wire use

it is possible to preview the spatial angulation to give to a gorge so that when the gorge is aligned with the wire, the tooth is properly positioned. This principle will be used in our study.

2.8-1 Help with diagnosis

2.8-1.1 General information (figures 70, 74, 75)

They are brought by the traditional software.

2.8-1.2 Teleradiographics (figure 71, 72, 73)

The automatic digitalisation of the points and the measurement of the angles are proposed on a digitalisation table. To do that, we will place the teleradiography on our digitalisation table identical to the SPE one and will indicate the points according to a strict order. The angles will be automatically calculated.

2.8-1.3 Arches

This is an important point to study. The fact of been able to do a reading of each arch, to model the teeth and to know each furrow and each cusp, enables us to know: the reference points of diagnosis as the centres in occlusion and to see the mal-position by comparison to the theoretical arches known that we use for bridges.

If the first and second category of data give us the possibility of an automatic diagnosis, the third category goes much farther. If we admit the positioning of the bracket at a precise place on the crown, it is possible to define the path to run, through the tooth, from the mal-position to the chosen position, in 3D. If we start from a position in linguo-version of 30°, neglecting in theory the bone factor, all we need to have is a bracket with a 0° gorge to get at the end of the treatment a tooth in good position (figure 97, 69). With these movements, it is necessary, in order to respect the bone factor, to use progressive angulation. It is possible in CAD/CAM to choose these angulations. They enable a soft and progressive movement.

CAD/CAM, associated with bone diagnosis, enables the exact definition of angular values every x day. Of course, the examples described previously are simple in terms of movement. The great superiority of CAD/CAM is being able to define the movement of the tooth and to calculate the movement curves in space while respecting the targets, that is to say the progressive change of pressure on the bone. The definition of a movement in space and the report of this calculation in the angulation of the gorge can only be the result of a complex mathamtical study that only one system of CAD/CAM can solve. The comparison with the theoretical arch, particularly, enables the prevision of each case, the thickness depending on the real theoretical curve and for each tooth.

Since 1982, we have worked on the automatic definition of the angular values and the distances. Today, we look to master the value of this angle (figure 66).

2.8-2 Therapeutics

The therapeutics are summarised, if the diagnosis is precise enough on the angular plan, to executing a bracket by varying the fixation angle of the wire. We rapidly notice that the manufacturing of a bracket is relatively simple for a CAD/CAM machine in 301/2 axes. Truthfully, 2 ½ axes are enough and the third axis will eventually only serve to manufacture the glueing surface with regards to the patient's tooth. As well as personalising the angle, we personalise the wedging surface, thus rendering the bracket's action more precise to respect the ark's effort (figure 68). It supposes from the dentist an impression of the occlusal surface and of the vestibular face of all the arches.

Currently, we develop a program of manufacturing enabling the setting of the angulation in space. By working on typodont, it will be possible to check the analysis quality of the software.

2.8-3 Verification and prognosis

Given that the whole of the analysis elements in the diagnosis work, it is possible to simulate, before the therapy, the result step by step on the screen. It enables to explain clearly to the patient the becoming of his mouth. Moreover, by taking regular impressions, it is possible to control the evolution of the work and the stage at which we are. Moreover, an action error will be detected by confrontation with the theoretical simulation thus avoiding some catastrophies.

Conclusion:

CAD/CAM and orthodontics lean, certainly on the quality of the diagnosis but mainly on the automatic determination of the position of the tooth with regards to the theoretical position. The modelling of the teeth and the extraction of the characteristic parameters that we know are the proper of this method (see crown). It enables not to neglect the real orientation wished in the space. All of our efforts will be on this estimation and on the quantification of the difference between real and theoretical. From there, the rest is simple. All you need to do in CAD is to define the movement and report it on mechanical pieces which will be manufactured. The same goes to the verification of the quality of the work. The generalist will find in this tool the possibility to master a domain he often prefers to give to the specialist.

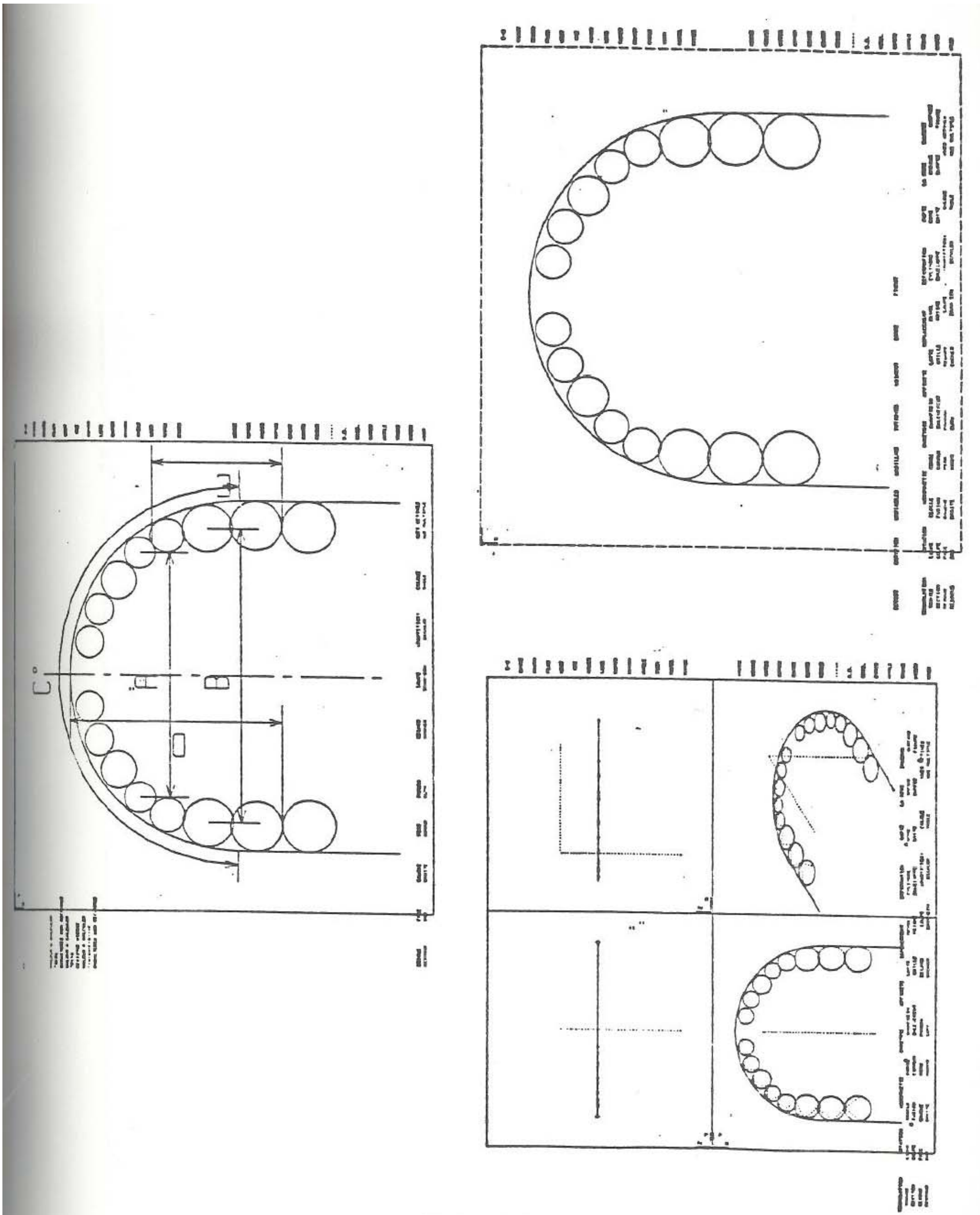
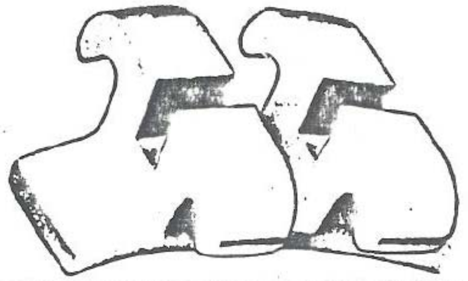


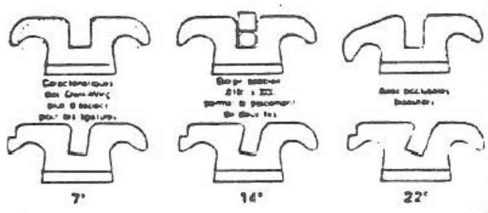
Figure 66



CARACTÉRISTIQUES

Le thérapeutique "Bioprogressive" (Ricketts) utilise des brackets à gorge de .0185 x .030 permettant un placement facile de l'arc et l'utilisation d'arcs et ressorts préfabriqués auxiliaires.

Les torques employés pour certaines dents sont de 7°, 14° et 22°.
Les angulations employées pour certaines dents sont de 5° et 8°.



BIOPROGRESSIVE STANDARD (RICKETTS)
Pour arc .0185 x .030 (0.470 x 0.762 mm)

SUPÉRIEUR

DENT	BRACKET	TYPE DOUBLE	ANG	PROFIL	DISTANCE GORGE/BASE	TORQUE	GORGE DROITE – AVEC PATTES POUR SOUDER SUR BAGUES – RÉFÉRENCE	GORGE DROITE – SANS PATTES SUR BASES POUR COLLAGE – RÉFÉRENCE	GORGE PRÉANGULÉE – AVEC PATTES POUR SOUDER SUR BAGUES – DROITE RÉFÉRENCE	GORGE PRÉANGULÉE – AVEC PATTES POUR SOUDER SUR BAGUES – GAUCHE RÉFÉRENCE	GORGE PRÉANGULÉE – SANS PATTES SUR BASES POUR COLLAGE – DROITE RÉFÉRENCE	GORGE PRÉANGULÉE – SANS PATTES SUR BASES POUR COLLAGE – GAUCHE RÉFÉRENCE
1|1 Centrales		Large	0°		0.7mm	+22°	A-69	A-5203	A-69		A-5203	
2|2 Latérales		Moyen	8°		0.7mm	+14°	A-213	A-5204	A-2000	A-2001	A-5230	A-5231
		Large					A-214	A-5205	A-2002	A-2003	A-5232	A-5233
3|3 Canines		Moyen	5°		0.7mm	+7°	A-468	A-5209	A-2006	A-2007	A-5236	A-5237
		Large					A-469	A-5210	A-2008	A-2009	A-5244	A-5245
4|4 1re Pré molaires		Moyen	0°		0.7mm	0°	A-996	A-5211	A-996		A-5211	
		Large					A-997	A-5212	A-997		A-5212	
5|5 2e Pré molaires		Moyen	0°		0.7mm	0°	A-996	A-5211	A-996		A-5211	
		Large					A-997	A-5212	A-997		A-5212	

INFÉRIEUR

DENT	BRACKET	TYPE DOUBLE	ANG	PROFIL	DISTANCE GORGE/BASE	TORQUE	RÉFÉRENCE	RÉFÉRENCE	DROITE RÉFÉRENCE	GAUCHE RÉFÉRENCE	DROITE RÉFÉRENCE	GAUCHE RÉFÉRENCE
1|1 Centrales		Simple	0°		0.7mm	0°	A-62	A-5214	A-62		A-5214	
		— ou —										
2|2 Latérales		Moyen	0°		0.7mm	0°	A-66	A-5200	A-66		A-5200	
3|3 Canines		Moyen	5°		0.7mm	+7°	A-468	A-5220	A-2020	A-2021	A-5242	A-5243
		Large					A-469	A-5221	A-2022	A-2023	A-5246	A-5247
4|4 1re Pré molaire		Moyen	0°		0.7mm	0°	A-996	A-5228	A-996		A-5228	
		Large					A-997	A-5229	A-997		A-5229	
5|5 2e Pré molaires		Moyen	0°		0.7mm	0°	A-996	A-5228	A-996		A-5228	
		Large					A-997	A-5229	A-997		A-5229	

SACHET DE 10

Figure 67

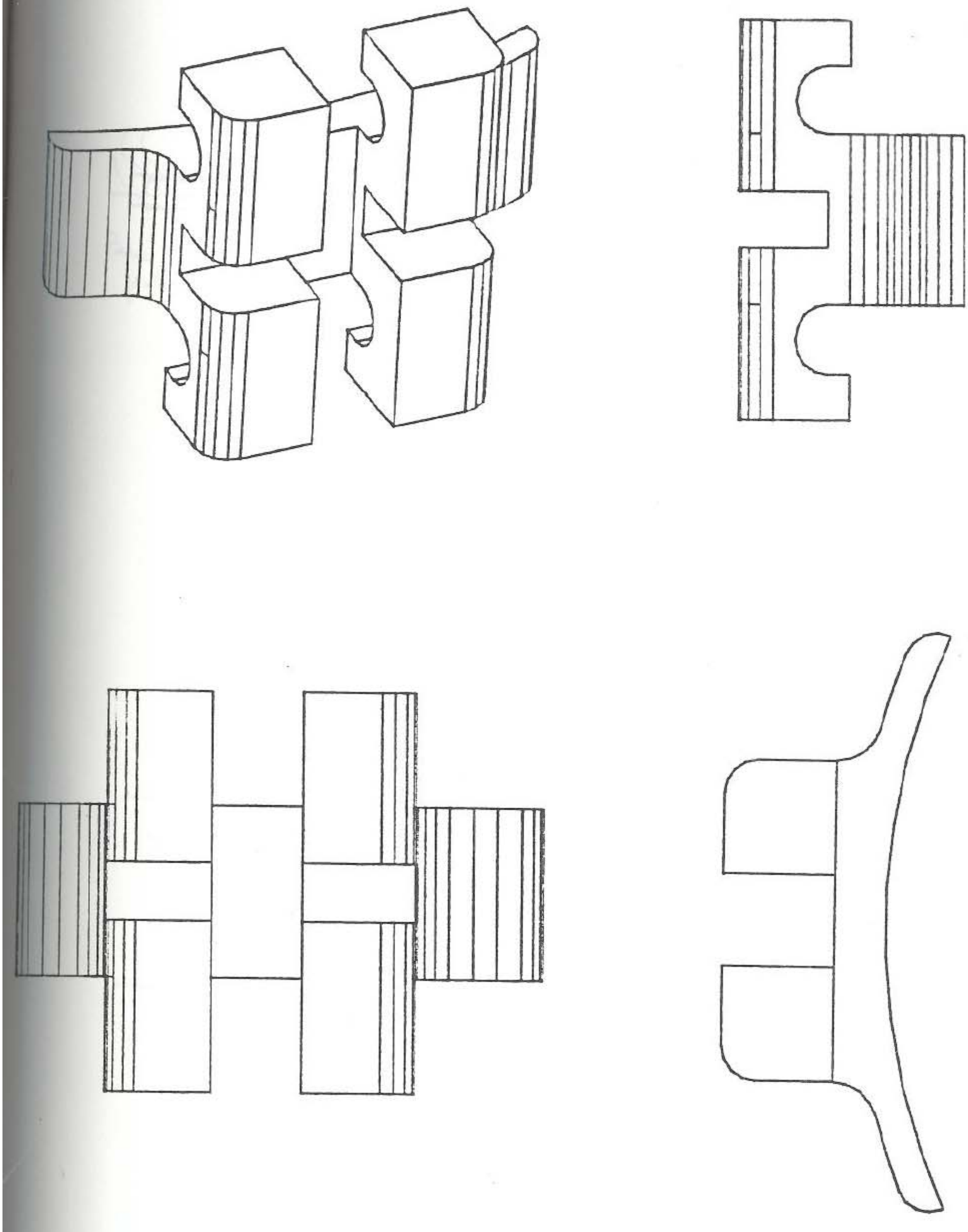


Figure 68

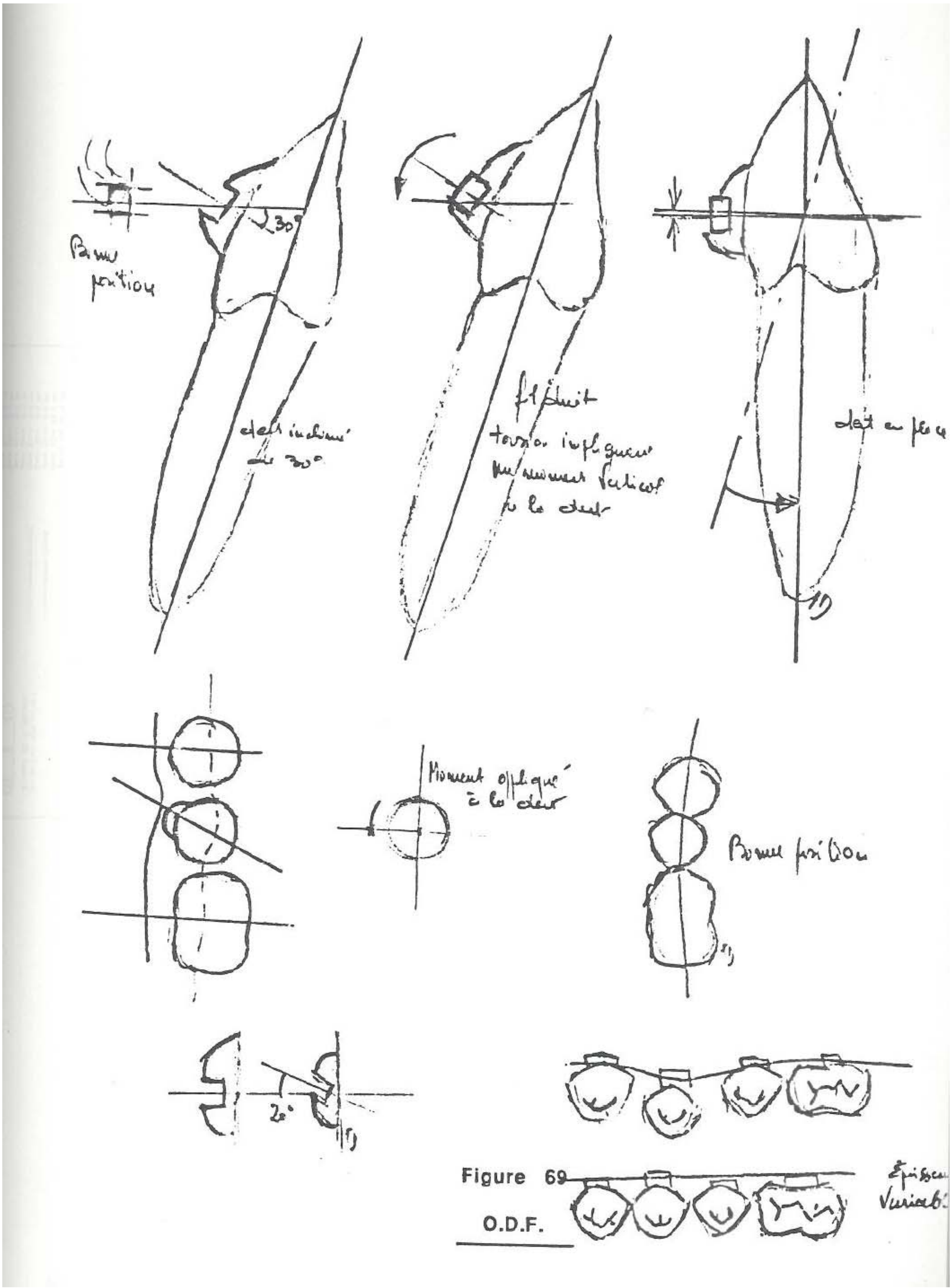


Figure 69

O.D.F.

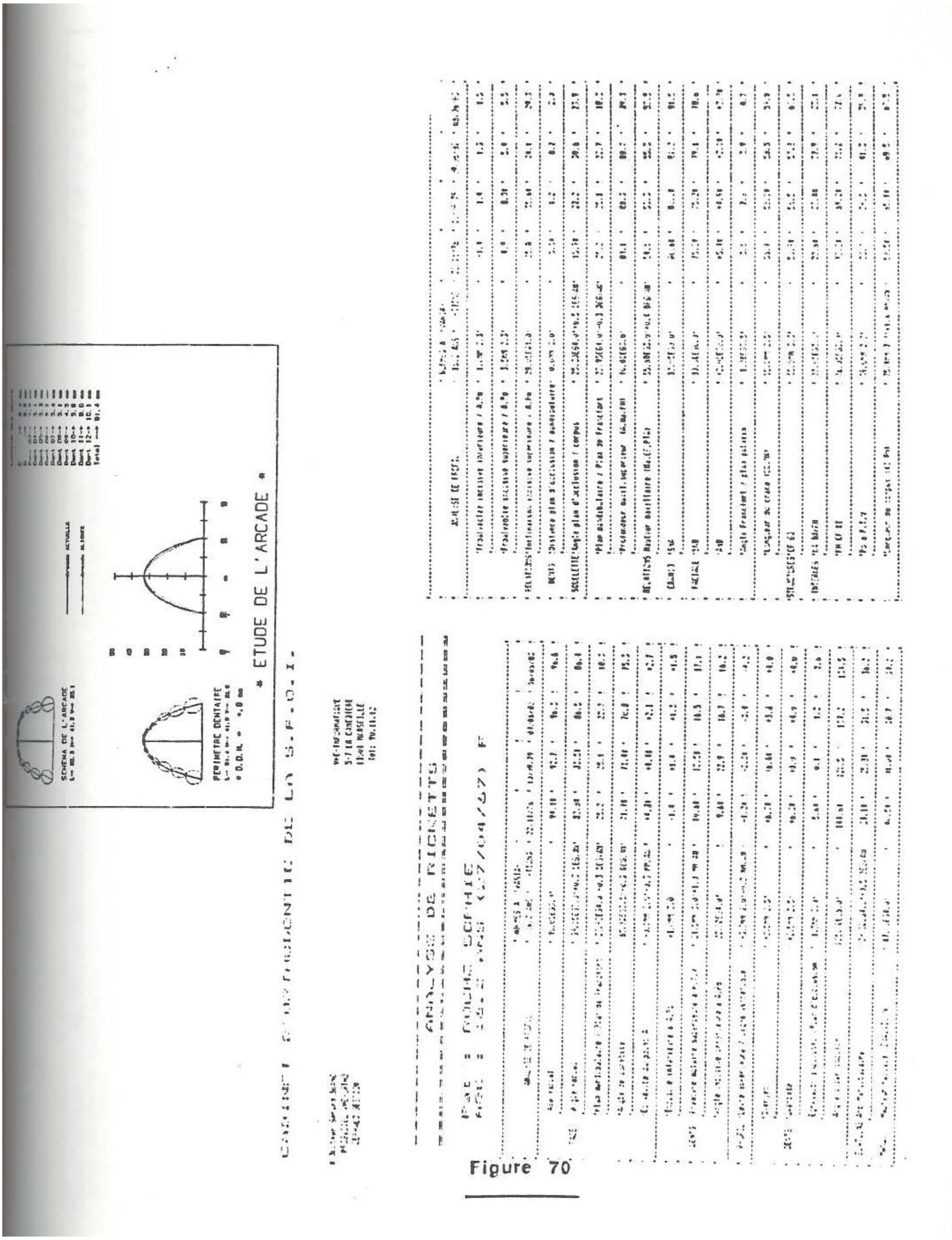

ETUDE DE L'ARCADE
ANALYSE DE RICKETTS
PERIMETRE DENTAIRE
SCHEMA DE L'ARCADE

Figure 70

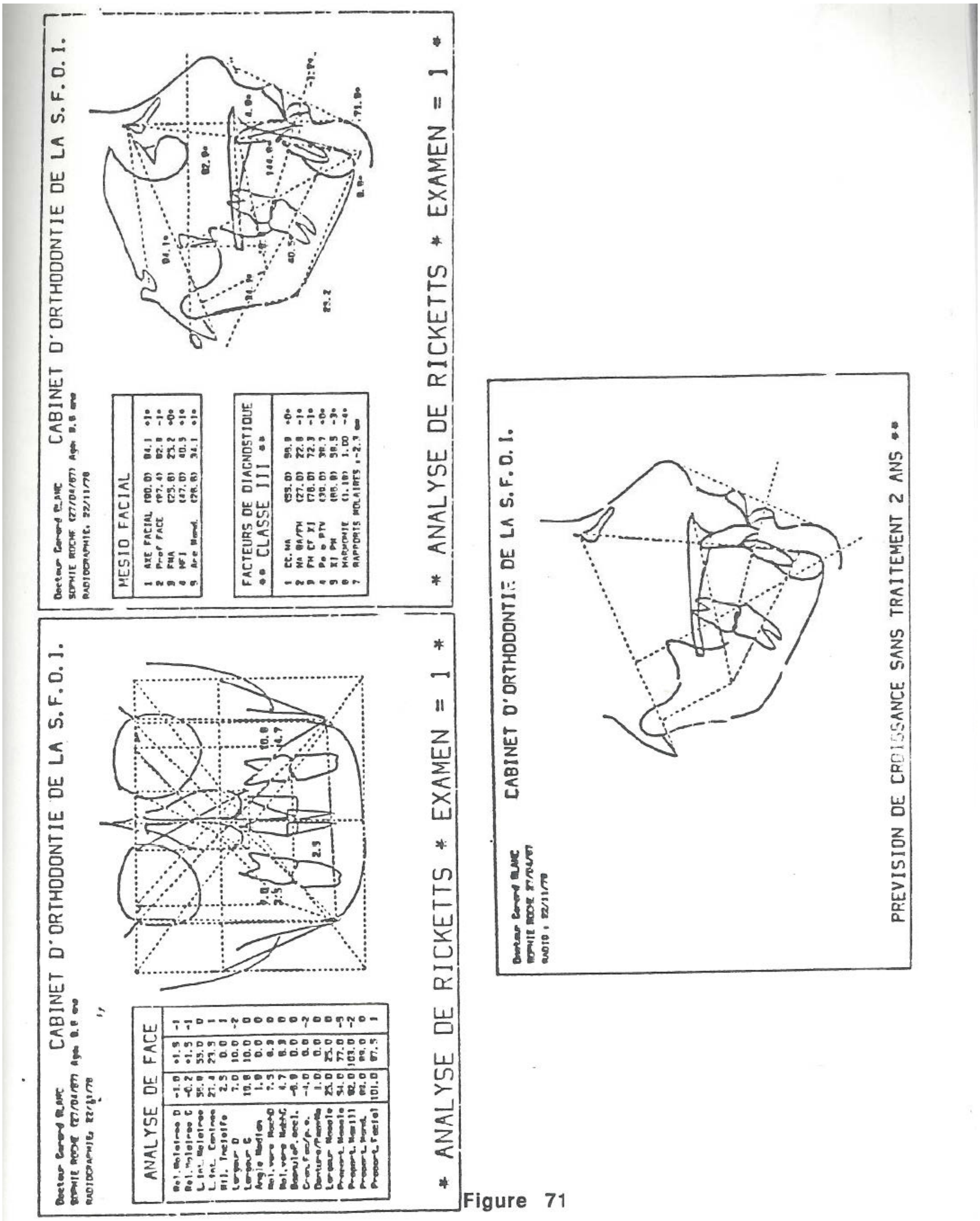

CABINET D'ORTHODONTIE DE LA S.F.D.I.
MESIO FACIAL
FACTEURS DE DIAGNOSTIQUE
** CLASSE III **
* ANALYSE DE RICKETTS * EXAMEN = 1 *
CABINET D'ORTHODONTIE DE LA S.F.D.I.
ANALYSE DE FACE
* ANALYSE DE RICKETTS * EXAMEN = 1 *
CABINET D'ORTHODONTIE DE LA S.F.D.I.
PREVISION DE CROISSANCE SANS TRAITEMENT 2 ANS **

Figure 71

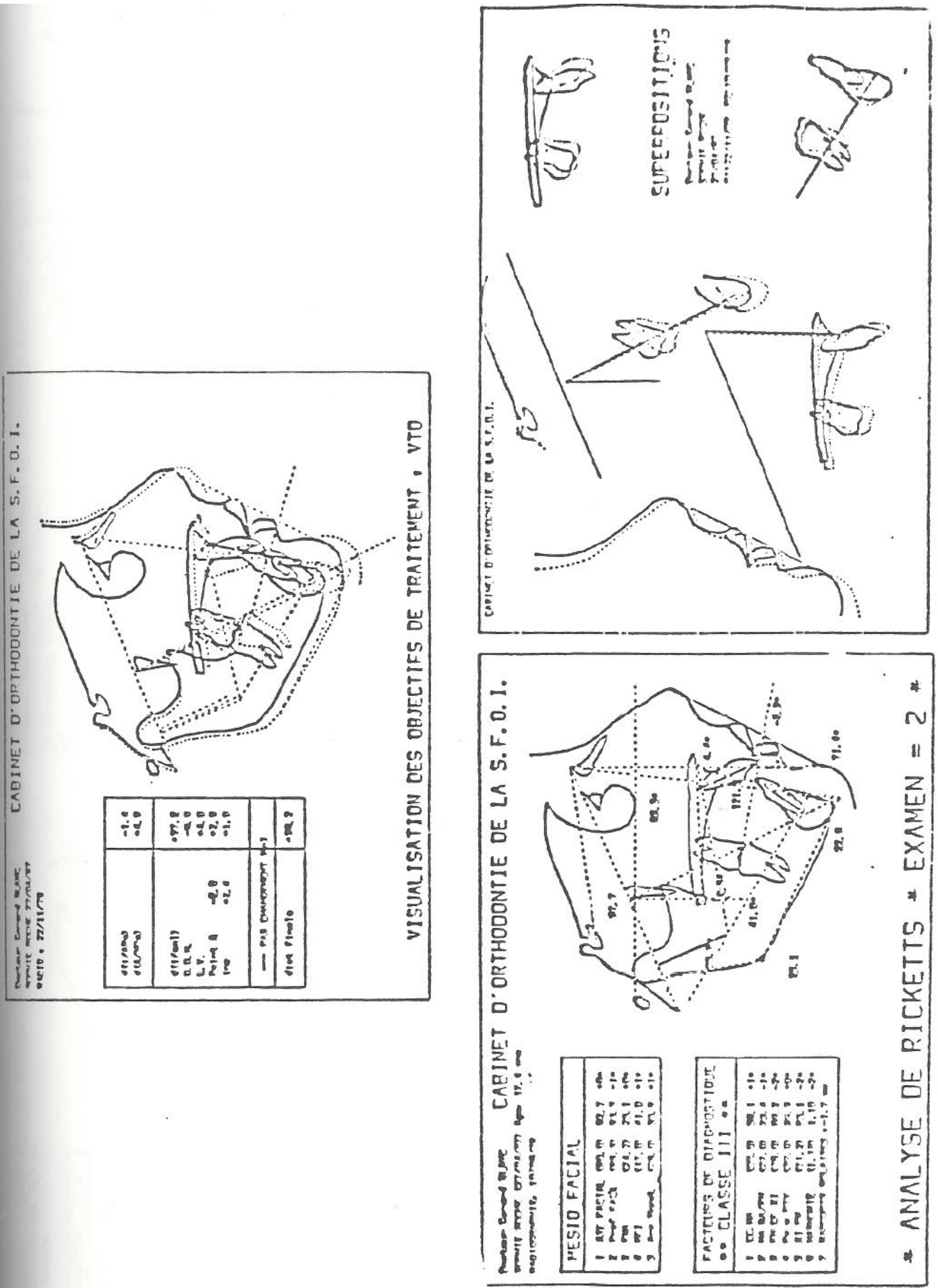
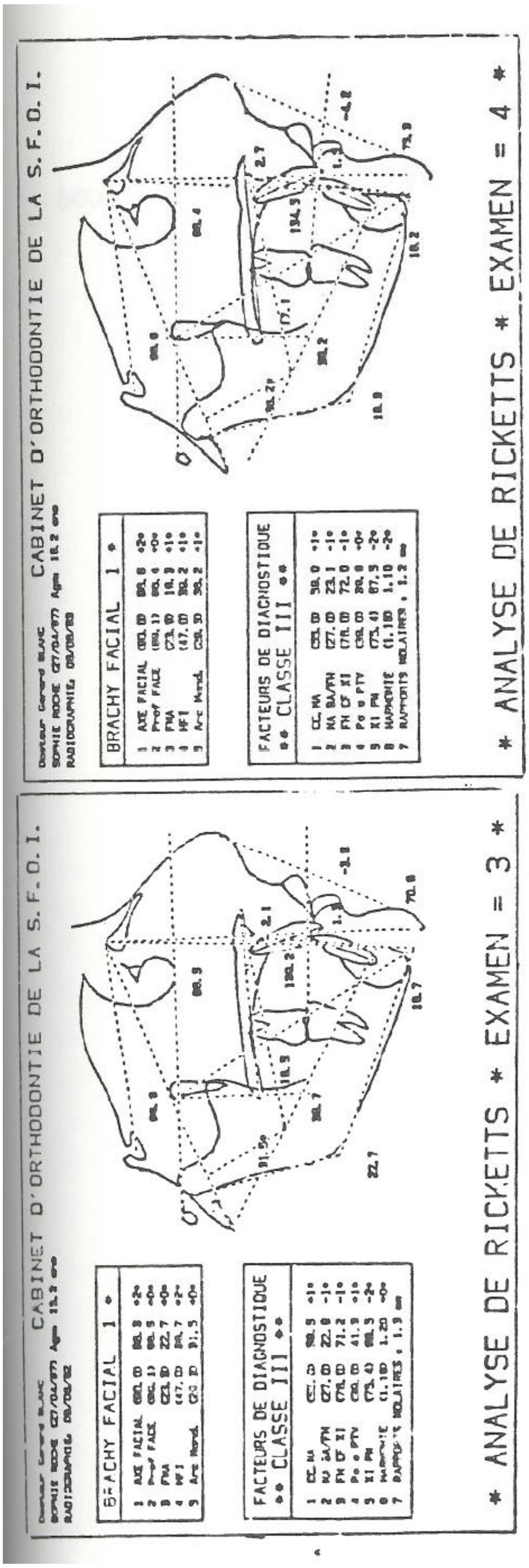

CABINET D'ORTHODONTIE DE LA S. F. O. I.
VISUALISATION DES OBJECTIFS DE TRAITEMENT , VTO
SUPERPOSITIONS
CABINET D'ORTHODONTIE DE LA S. F. O. I.
MESIO FACIAL
CLASSE III
* ANALYSE DE RICKETTS * EXAMEN = 2 *

Figure 72


CABINET D'ORTHODONTIE DE LA S. F. O. I.
BRACHY FACIAL 1 *
FACTEURS DE DIAGNOSTIQUE
** CLASSE III **
* ANALYSE DE RICKETTS * EXAMEN = 3 *
CABINET D'ORTHODONTIE DE LA S. F. O. I.
BRACHY FACIAL 1 *
FACTEURS DE DIAGNOSTIQUE
** CLASSE III **
* ANALYSE DE RICKETTS * EXAMEN = 4 *

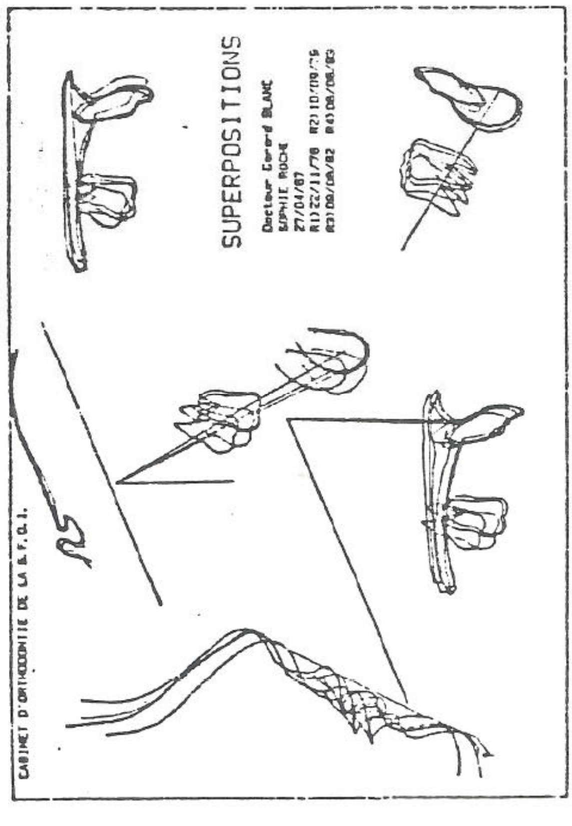

SUPERPOSITIONS
CABINET D'ORTHODONTIE DE LA S.F.O.I.

Figure 73

2.9 Precision

2.9-1 Correlation and modelling precision

We have spoken, in the previous chapter, about the precision of the relief measurement. We have seen that the optical probe could deliver, in certain measurement conditions, impressions in semi points having a certain imprecision, mainly coming from of, on the one hand, the phase measuring noises and on the other, uncertainties of the calibration procedures. The impressions are referenced to a plan which is linked to the probe and to its orientation; the **reference plan**. For each impression, we have a referential system which is associated to it. The modelling step consists of:

a- gathering the points from the different impression in a same referential, it is the **correlation**.
b- adapting the relief data thus obtained following a format which is compatible with CAD software, it's the **modelling**.

2.9-1.1 Correlation precision

The current principle of the correlation consists of placing the relief to be acquired, points which are easy to find. These points are interactively detected on each impression and are then used as base for the calculation of a referential common to each impression (system of axis associated with the marking points). For each impression, the coordinates of the points of the relief are transformed (rotation and translation) to refer to the marking points. We thus obtain several semi points with the same referential. The precision of this correlation is evidently linked to the precision of detection of the marking points but also to their positioning in space. With the current methods of detection, the precision of a point is around 30µ depending on the 3 axes. We use three points. If these three point are for example 20µ apart, the correlation error will be 20 times the marking error. We can summarise this leverage effect by the approaching formula that follows:

$$E_C = \frac{E_R \times D_P}{D_R}$$

With

E_C is the correlation error for a given P point

E_R is the marking error (around 30µ)

D_R is the average distance of three marking points to their barycentre

D_P is the distance of the studied point to the barycentre of the three marking points

We see that the more the marking points are far apart from each other and the closer they are of the studied object, the lower the correlation error is.

REMARK: to palliate this leverage effect, we have imagined the completion of this correlation method by a micro correlation step which, starting from the correlation results, detects by using the relief's curves, the zones effectively common to the two semi points and which deduces an adjusting transformation. This software is still at the development stage.

2.9-1.2 Modelling precision

Modelling has a double role:

a- eliminating the aberrant relief points
b- interpolate the semi points by function

The CAD softwares aren't generally done to receive a lot of points. It's even the contrary, with few captured points by man on screen, these softwares are capable of generating several million. For example, a circle will be defined by three points, a Beziers curve by a dozen maximum. However, the circle and the Beziers curve have an infinity of points! In our case, we must do the contrary: the probe delivers a very important quantity of points (around a million for a good impression capture). Evidently all these points aren't useful but they constitute a good statistic base. Their characteristics are as follows:

- their density isn't constant all over the relief
- they are ordinates
- some are wrong

With these processes of smoothing then skeletisation, we eliminate the aberrant points, ordinate the points and give a more or less density. Then we approximate the semi points with binomial functions or with z buffer functions, in order to reduce the number of parameters transferred to the CAD. In terms of precision, this modelling improves the global quality of the relief while generating smoothing effects on some small details. It is very difficult to quantify this grain but everything happens as if we selected the more precise semi points on the curve or on the surface (tendency and lesser square).

2.9-2 CAD software precision

In a general manner, the precision of the software is closely linked to the precision of the calculator. The codification of the numbers in a computer is obligatorily edged.

It means that each number can only be expressed with a certain number of figures after the comma. In the calculators we use, the coding of the digital data is done following a standard internationally recognised which is called "floating comma". With this mode, we have a precision of 7 numbers after the comma. Knowing that the unit we use is the millimetre, the precision of the calculation will be $10^{-4}\mu$. We must add to this hundreds of degradations which are proper to each calculation module.

2.9-2.1 Precision of CAD calculation

The calculations done by the software generally use interactive algorithms. On the other hand, several calculations using the results of the previous calculation can add to each other. The multiplication of these operations leads to a degradation of the precision and "edge effects". Fortunately, we have the means to limit this "inflation" by working on intermediary partial results with a more precise representation. This costs some time but avoids rapid degradation.

Let's take an example: let's suppose that the machine only accepts two numbers after the comma and that we must multiply 1.13 by 9.99. Seeing that these two numbers have each two number after the comma, and that the result will also have two, it will cut them by one number, 1.1 and 9.9 and will give 10.89 as a result. If, on the contrary, we program 10 x 1.13, then 10 x 9.99 and finally divide the result by 100, it will do:

10 x 1.13 = 11.3
10 x 9.99 = 99.9
11.3 x 99.9 = 1128.87
1128.87 / 100 = 11.23, which is more than 10.89.

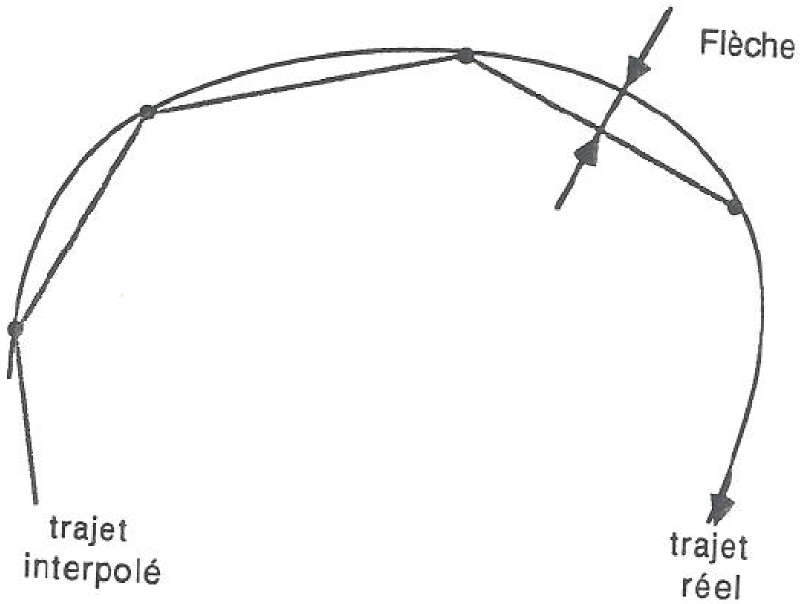
For the softwares we use, the precision for the final results is 10^{-6} x DIMEN, where DIMEN is the dimension of the working space which can be different depending on the work done (stump, crown, occlusion, bridge…). But even if we are placed in an unfavourable working case, for example 45 x 25 x 15 mm3, the error is only 0.045% in z, 0.025% in y and 0.015%in x.

2.9-2.2 Precision of interactive

We must distinguish here two very different cases. When the dentist captures a point already existing on the screen, the precision of capture is internal to the software, thanks to a particular procedure which goes to the closest point indicated by the practioner (readjustment on existing curves). When the dentist captures a point that doesn't exist already on the screen, the precision of the pointing is the pixel. Thanks to the "magnifier effect", it can become important. Let's suppose a 10mm high curve. For a screen of 1000 by 1000 points, the capture precision will be 10µ. But if we take a part of the curve, for example 1mm of it and we do a "magnifier effect" on it, we still have 1000 by 1000 points which leads to a 1µ precision. We see that we can get an adapted practice of the visualisation screen, a very important precision of the capture of points.

2.9-2.3 Precision of manufacturing movements

After having generated the prosthesis, the calculator launches a particular procedure which enables the calculation of parameters to be sent to the tool machine. It only knows how to execute linear movements. We are going to approximate the shapes found by a succession of segments of a line. We could do this infinitively but the limit is imposed by the speed of transmission of the coordinates to the digital command on the one hand and the speed of execution of the order on the other. If we generated too many points, the manufacturing time would become prohibitive and the movements would be interrupted during the waiting of the transmission. To limit ourselves and to keep a certain precision of the manufacturing movement, we have determined an acceptable maximal arrow. This arrow corresponds to the maximal distance between the real curve and the segment of line joining two points sent to the digital command. It corresponds typically to the precision of the manufacturing movements and is 20µ today.



3-MANAGEMENT SOFTWARE

3.1 Generalities

Management must be a constitutional element of CAD/CAM. Particularly each practioner possessing this device must have a logic management capacity, quick and organised, given the power of the used material. It is particularly interesting to note that a practioner who invests 100000FF of management material pays 1/5th (20%) of the CAD/CAM and who wanted to computerise his management will pay his CAD/CAM 20% less. It is also a marketing operation as well as a medical operation (with the difference to other sectors).

There are today around 80 softwares of dental management and only a dozen are really operational (figure 74). For CAD/CAM, we have preselected 10 following these conditions:

- software tested by numerous colleagues , as, if this software was to be sold in numerous copies, it means it corresponds to a good analysis of the dentist's needs. Moreover, it's a pledge of achievement for the company that commercialises it
- multi-practioner's software, as the market aimed at by CAD/CAM is oriented towards grouped practices
- a software recognised by the A.N.E.R.I.O., which guarantees a certain quality of the software
- a software representing a technological advance as we must be on top today to be ready tomorrow…

PRELIMINARY REMARKS:

The pre-selected softwares are recognised at a national level by a group of colleague fans of computer science and impartial. Then, we have eliminated the doubtful ones because of the reliability of the companies who support them and those whose analysis banality isn't compensated by the number of sold systems.

The kept softwares are as follows (first analysis):

- AGATHA
- ALPHADIS
- APOLLINE
- DENTILOG
- DENTPRO
- GESDENT
- JULIE
- PAROLOG
- PRODENT
- VISIODENT

Each software enables, after study:

a) The management of patients
An identity sheet with management of birth dates and management of homonyms.
Patients clustering
Medical questionnaire
Treatment plan
Colour graphic dental drawings
Quotes
Orders and counter indications
Care sheet with both sides printing
Prior agreement with both sides printing
Management of non payment, reminder letters
Management of private insurance
Appointment management

b) Accounting
Receipt book
Expenditure book
Depreciation book
Big book
2035 declaration

c) Other
Salary
Stock management
Statistics (actions, time, etc…)

We must insist on the shyness of our colleagues, in front of computers (less than 1500 practices are equipped out of 37000 dentists, which means around 4% of dentists and 7 to 8% of practices) (figure 74).

3.2 Current study

Two softwares have been chosen. They are PRODENT from CERILOR and ALPHADIS from ALPHAMET.

3.2-1 HENNSON's policy

As we have defined previously, the HENNSON Company doesn't have a vocation of recreating a management software but to offer one or more software already written to his buyers and for free. The company responsible for the software will install it and insure the maintenance. The market in the first place concerns mono-posts but will be increased to multi-posts. CAD/CAM won't have a printer, a slight over cost will have to be planned.

3.2-2 Prodent (CERILOR company) – Doctor DESPREZ in Maxeville

The PRODENT software uses UNIX which seems incompatible with VMS and is in C Microsoft. We need to transfer all of PRODENT under VMS and rewrite the entry and exit routines (hard drive, screen). What are the problems being solved? (PRODENT on CAD/CAM must be presented in November 1987).

3.2-2.1 Problems linked with translation

The C Microsoft is an on-set of the KERNIGAN RITCHIE norm. The C Vax is under the same on-set. At first, two compilers are able to translate the "norm". Practically, the on-set doesn't exist (simple adjunction of identification key words). If the translators are close, the pre processors are different. IT leads to recognition problems for the implantation the objects done by the compiler.

3.2-2.2 Problems linked with links edition libraries

PRODENT uses 60 functions planned or not by the Vax library.

3.2-2.3 Problems with installed configuration

PRODENT needs 640 KO of RAM.
1.5 MO for programs and tables
7 KO per sheet (5 MO for a lifetime)

This conforms with CAD/CAM but there is still the connection problem. We are transferring PRODENT under BERKELEY 4.2, from Unix thanks to Vax 750 available. From October we will transfer on VMS with availability of a Vax for 2 to 3 months (analysis and tests).

3.2-3 Alphadis (ALPHAMET company)

The ALPHADIS software is written under RSX to use Microvax PDP II. The language is written under RPL whose license is 50 000FF for each user! This cancels all possibility of use. The principle would be, here again, to rewrite the software in Basic Plus for which the license price is null. We have decided to help M. VIDAL with this work and have charged an engineer to do this. To do this, a study has been made:

- working tools at our disposal (for both companies)
- licensing costs for the softwares (use)

We noticed that:

- the unavailability of Basic Plus 2 on Micro Vax, replaced by Vax Bass
- the licenses are very expensive

  35 920FF for DATATRIEVE

  15 120FF for TDMS

  7 235FF for CDD

If it is possible to have a software quickly, unofficially, we can't beneficiate of the documentation (!) and the logistical support. There would not be a fee to pay for the final user (dentist) for the programming languages but a Run-Time (use rights) license for TDMS of 6 006FF would still be obligatory. Unfortunately, the absence of competence for these transcription softwares and the high cost of the official versions will oblige ALPHAMED to abandon this way in July (23/07/87).

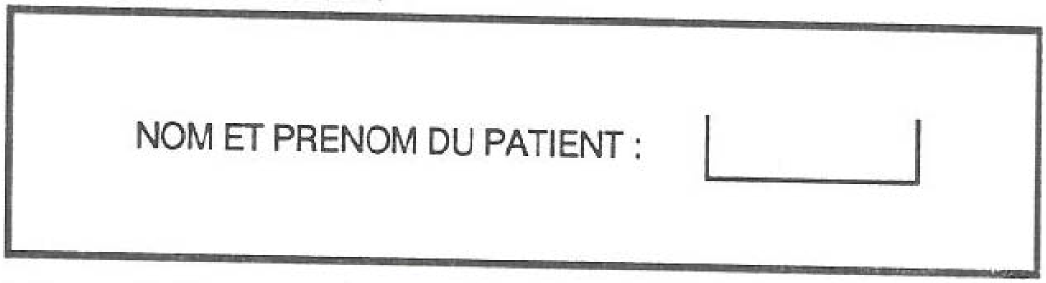
Recently (August), DIGITAL has offered a special Multi-use license of 25 427FF. Even if this price varies from Station 2000 to Micro Vax (reduction of 50%), the price stays too high. Moreover, DIGITAL is amazed if the use if CDD and DATATRIEVE as a management software as, according to them, these are very greedy and not adapted to Micro Vax. A more thorough study of the ALPHADIS software showed that this software was very powerful and needed lots of space on the hard drive. Moreover, the multi-use causes a certain number of problems and the providing of the license for Micro-VMS 2 Users with our PCs seems insufficient for our management software.

Finally, ALPHAMED has decide that, after seeing DIGITAL's prices, abandoning the CDD environment and so TDMS and DATATRIEVE was the best solution and the rewriting of the whole software in Basic would be done. This increases the development phase but it has started end of July and should be finished in November.

3.3 Particular interactive development by HENNSON

From April to June 1986, HENNSON has received an intern, Christiane ACHARD, in order to develop an interaction of management of prosthetic data in CAD/CAM. This software enables the management of the patient's sheet to whom we are doing a prosthesis and possibly transmit the data to a management file in a dental practice. This work was the subject of an internship dissertation and numerous clinical trials. The software was written under FORTRAN 77 with EUCLID (MATRA DATAVISION).

During the launch of the software, a capture of the name and surname of the patient runs. We have the first screen (see below):



Two cases can happen:

1ST CASE: the concerned patient is already in the database of the general CLIENTS file and has a care sheet
In this case, the program will display the VT 220.

2ND CASE: the patient is a new client of the dentist and not yet entered in the database. We must create his care sheet and insert a new recording in the general CLIENTS file.

We will send the data on the VT 220 but the menu of restrained command with three commands which are F for END, V for VALIDATION and M for MODIFICATION. Before sending to the VT 220, the treatment of homonyms will occur, that is to say the program will "sweep" the whole general CLIENTS file to see if there is already a patient with the same name and surname and the current patient. Two cases can logically occur:

- there are no homonyms. We go directly to the second VT 220 screen and create a new patient (figure 75).
- there is one or more homonyms, the program will send a list of this or those homonyms and ask to capture the chosen patient's number or will enable by typing on the keyboard a special N° (sent to the screen) to create a new patient (or new homonym). For the dentist to make a choice in the list, we had to send a screen line per patient with the minimum identification criteria.

We have chosen to put on this screen line:

- the patient's number
- the surname + name
- the complete address
- the social security number

In the 2nd case, only the Name and Surname and Number zones will be sent by the program, the others have to be captured. At the end of the display or the capture, the user will type the command of his choice on the keyboard (I…). All the commands have very precise functions that can be read on the screen.

We then have the following question on the screen:

DO YOU WANT TO START THE CAD WORK? [_]

(O = Yes / N = No)

If the answer is "N", we exit the program.

If the answer is "O", we will have the following question on the screen:

NUMBER OF THE TOOTH TO BE TREATED: [_]

This number must be between 11 and 48 for adult patients. There will then be an update of the last visit in the CLIENTS file. If the archive date isn't null, we will restore the patient's backup file otherwise we will do no treatment. That's when we start the CAD phase and the 5th screen appears. If the answer is "N", the program will add a recording in the care sheet file with the date, the number of the treated tooth and the nature/intervention/blank zone. If the answer is "O", a menu offering different types of prostheses appears on the screen. All the dentist has to do is choose and type the first two letters of the chosen name.

If his choice is = "CO" which means CROWN, another menu is displayed offering possible types of crowns. In this case also, the dentist will only have to type on t he keyboard the first two letters of the chosen type.

If his choice is = 3BR" which is BRIDGE, the dentist will have to answer the following question:

NUMBER OF ELEMENTS: [ ]

(=2, 3, 4 or 5)

Then the program will send him back to the types of crowns menu (see treatment for the choice = "CO").

If his choice = "IN", that is to say INLAY, the dentist will have to answer:

NUMBER OF FACES: [_]

(= 1, 2 or 3).

Whatever the choice of the dentist, the program will add a recording to the care sheet file.

This last phase finally concerns the handling to the users of the management database EUCLID. We will have on the screen the following question.

SAVE CAD WORK?: [_]

(O= YES / N = No).

If the answer is "N", there will be no saving of the work done with the CAD software

If the answer is "O", the main software will launch the DCL command file: SAUVEGD.COM which will be immediately executed under EUCLID. The binary saving file will be under the form:

PATIENT N°.DAT

We will also have an update of the last backup date for the concerned patient in the CLIENTS file. In both cases, the database will be emptied or "cleaned" to initialise at the next working session. It is the end of the program. The work has be built in order to establish solid links with the ALPHADIS software.

3.4 Conclusion

Two softwares are being used. The HENNSON software will have to, in the first instance, work in parallel with the management softwares and in the second instance, a link will be built for interactivity with only one processor.

REPERTOIRE DES PROGRAMMES LE 27 JANVIER 86

DOS	NOM DU PROGRAMME	VENDEUR	ADRESSE	CODE POSTAL ET VILLE	TELEPHONE
CANON X07	INFORMATIQUE CDP	DOCTEUR LABOUZE	61 RUE DULONG	75017 PARIS	47-63-08-02
COMMODORE	DENTEX TRG	DOCTEUR TOLLET	EUDAL DE BAS URVILLE	50460 NACQUEVILLE	33-03-97-09
COMMODORE	SEMIDENT	MR MUHLA	69 RUE DE MAREVILLE	54520 LAXOU	83-40-43-38
CP/M	ARDION	MR VINCENTI	18 AVENUE BEAU PLAN	13013 MARSEILLE	91-66-12-40
CP/M	CIDENT	SILMM	B.P. 39	56530 QUEVEN	97-05-24-34
CP/M	MICRODENT	MR FOIX	21 BIS AVENUE SAINTE MARIE	94160 SAINT MANDE	43-65-25-30
CP/M	NC DENT	NORD CONCEPT DIFFUSION	5 RUE DU COLIBRI	59650 VILLENEUVE D'ASCQ	20-05-42-02
DOS 3.3	AGATHA	DOCTEUR GAUSSEN	59 BIS RUE DE LA BICHE	30000 NIMES	66-76-04-75
DOS 3.3	AGCODEM	MR PEREZ	22 RUE DE LA VICTOIRE	75009 PARIS	48-78-27-66
DOS 3.3	CHIRDENT DPR	DPR FRANCE	103 BD NATIONAL BP 44	92502 RUEIL MALMAISON	47-08-36-10
DOS 3.3	COMPODENT	MR AZOULAY	181 RUE TRIAIRE	92500 NANTERRES	42-04-03-95
DOS 3.3	CORRESPOND-DENT	DOCTEUR ESKENAZI	68 Bd MIREILLE-LAUZE	13010 MARSEILLE	91-79-85-82
DOS 3.3	DENTISET	SANTE SET	TOUR ORION 5 RUE KLEBER	93100 MONTREUIL	48-51-91-00
DOS 3.3	MAI DISK	A.G.D.	48 BD ALEXANDRE MARTIN	45000 ORLEANS	38-54-45-13
DOS 3.3	ODONTO-LOGIC	MR LETOURNEUR	32 RUE DE LA VICTOIRE	75009 PARIS	48-74-79-96
DOS 3.3	PRODAVIER DISK	MR ANDRE AMAR	5 RUE JEANNE D'ARC	94160 SAINT-MANDE	48-08-64-35
DOS 3.3	SGCD	MR VERSLUYSEN	6 RUE DE CHATEAUDUN	75009 PARIS	48-76-60-63
HP 150	DIGIDENT		11 RUE TRONCHET	75009 PARIS	42-66-40-34
HP 150	EVI-DENT	VHE INFORMATIQUE	5 LA CANEBIERE	13001 MARSEILLE	91-90-67-50
ITT 3030	DIALOG	MR BRAULT	38 BOULEVARD DU CHATEAU	92200 NEUILLY SUR SEINE	42-42-00-37
MAC	GESDENT	LOGI 27	73 RUE TURBIGO	75003 PARIS	42-74-70-55
MAC	MAC DENT	DAG INFORMATIQUE	38 BIS RUE DES GRANGES	69005 LYON	78-36-48-19
MS-DOS	ABSOLU	MR LATAPI	209 RUE DE BERCY	75012 PARIS	43-46-13-95
MS-DOS	ADENT	PROMOTEC	113 AVENUE APOLLINAIRE	69009 LYON	78-64-16-66
MS-DOS	APOGE	DOCTEUR GARIN	17 RUE AUGUSTE	30000 NIMES	66-21-00-88
MS-DOS	ARTHUR	MR VELU	IMMEUBLE LA TRAMONTANE	84300 CAVAILLON	90-71-42-45
MS-DOS	BASEDENT	DOCTEUR BERCY	5 RUE DU 4 SEPTEMBRE	13100 AIX EN PROVENCE	42-38-54-46
MS-DOS	BIBLO	VAO COMMUNICATION	41 RUE MARIUS AUFRAN	92300 LEVALLOIS PERRET	47-58-40-67
MS-DOS	CERG DENTAL	PROMODATA	10 AV. DE LA GRANDE ARMEE	75017 PARIS	45-01-54-13
MS-DOS	CIT DENT	MR THAHERALY	8 BOULEVARD DES ARENES	30000 NIMES	66-76-07-72
MS-DOS	DENTISYS	MR NGUYEN KHANH	OCFD 7 BD DE L'EUROPE	21800 QUETIGNY	80-46-01-25
MS-DOS	DENTPRO	MR RAOUIDEL	21 RUE CHAPTAL	75009 PARIS	48-74-60-64
MS-DOS	FMI DENTAIRE	MR JEAN-MARIE KURT	2 RUE CURNONSKY	75017 PARIS	47-58-12-72
MS-DOS	GID	DOCTEUR MEDIONI	41 RUE GUERSANT	75017 PARIS	47-33-30-03
MS-DOS	INFODENT	MR MICHEL DEMANGEON	23 RUE DE BREST	69002 LYON	78-42-49-27
MS-DOS	INFORM ET SANTE	MR CHIROUZE	46 RUE LAFAYETTE	75009 PARIS	42-85-12-88
MS-DOS	IVOIRE 2	PARTNER INFORMATIQUE	33 AVENUE DE GRAVELLE	94220 CHARENTON	48-93-23-87
MS-DOS	JULIE	CENTRE INFORMATIQUE	4 RUE DE LA MADELEINE	45140 ST JEAN DELARUELLE	38-43-27-27
MS-DOS	KARIANE	DAI	166 AVENUE DE HAMBOURG	13008 MARSEILLE	91-72-23-56
MS-DOS	ODUS	MR GEHIN	13 RUE MOLIERE	75001 PARIS	42-96-05-52
MS-DOS	PRODENTIS	MR BORG	4 RUE FOUCROY	75017 PARIS	42-67-74-57
MS-DOS	STADENT	MR CARO	53 AV. PHILIPPE AUGUSTE	75011 PARIS	43-72-21-66
MS-DOS	VISIODENT	DENTAL COMPUTER	94 RUE LAFAYETTE	75010 PARIS	42-46-81-05
OASIS	DENTILOG	MR TSIRANANA	46 RUE SAINT ANTOINE	75004 PARIS	42-78-26-64
OASIS	DENTILOR	MR LAMOTTE	35 AVENUE DE L'OPERA	75002 PARIS	42-96-63-59
OASIS	DENTILOV	MR CHEVALLIER	26 RUE DE BERRY	75008 PARIS	45-62-50-15
PROLOGUE	ITTIDENT	DOCTEUR BEUGNET	23 RUE DE LA NOUILLERE	25000 BESANCON	81-50-42-67
PROLOGUE	MANDIBULE	OGI NORMANDIE	21 RUE GUY DE MAUPASSANT	27000 EVREUX	32-31-16-77
RAINBOW	DENTO	MR COLLARD PLM	46 RUE DE LA THIBAUDIERE	69007 LYON	78-69-38-70
SANCO	ALLIANCE	MICRO 89	10 ALLEE DES ALOUETTES	89100 SAINT CLEMENT	86-64-35-74
SANCO 700	ISH	ISH	6 RUE GOETHE	75016 PARIS	47-23-31-05
SORD M23	GOLD	S.E.S. INFORMATIQUE	18 AVENUE DES CHAMPS-ELYSEES	75008 PARIS	47-23-78-20
UNIX	PRODENT	DOCTEUR J DESPREZ	17 RUE GAMBETTA	54000 NANCY	83-35-13-61
	ALPHAMET	J-M VIDAL	1 RUE HOCHE	83000 TOULON	94-92-98-18
	APOLLINE	MR MONTILLOT	6 RUE BEONEGNE	21000 FREMYOT DIJON	80-41-67-4

Figure 74

```
DOCTEUR : [----------]
PATIENT : [-------------]
   DATE : [------]
DENT N° : [--]
```

```
OBSERVATIONS INTERVENTION : [__]
      (O=OUI/N=NON)
```

```
        FICHE DE SOINS DU PATIENT

   NOM ET PRENOM :  [-------------]
          NUMERO :  [-----]
 DATE NAISSANCE :  [----------]
   DATE DU JOUR :  [----------]
        ADRESSE :  [------------------]
N° DE TELEPHONE :  [------------]
       N° DE SS :  [---------------]
   OBSERVATIONS :  [------------------]

   COMMANDE : I pour LIRE INTERVENTIONS
              A pour ANNULER LE CLIENT
              D pour LIRE DONNEES
                     ANATOMIQUES
              M pour MODIFIER
              F pour FIN
              V pour VALIDATION

      CHOIX ? : [__]
```

Figure 75

4-MANUFACTURING

4.1 Launching of digital command tool machine

4.1-1 Introduction

It is absolutely necessary that a dentist has no specific intervention to do when launching the machine. For that reason, from May 1982, we decided to use a direct correction command, through CAD and from June 1985, the launching of the machine was automatic. By semi automatic, we mean:

- verification of the mechanical characteristics
- resetting to zero of the working axes
- calculation of the automatic tools movements
- library of stocked tools
- choice of tool

During the ADF, all these operations, even they didn't really need a great control, were manually started. It meant:

- that the dentist had to possess a specific terminal for the tool machine
- that he had to command the starting of these instructions by direct manual action at each step and for each tool. From mid 1986, a library of tools, applicable to any type of prosthesis was defined, and only in March 1987 did we manage to develop the automatic launching of the machine.

4.1-2 Current state

The launching of the digital command and control of the tool machine process was entirely automated. It is a detached process to do in parallel the resetting of the axes of the machine, the calculation of the movements, the manufacturing of the pre shape and the manufacturing of the tooth. The CAD post is available for calculation of a new prosthesis or other things.

4.1-2.1 Launch

When a practioner has finished is interactive or automatic action, all he has to do is indicate "manufacturing". The application launches under process to take the manufacturing in charge. The process, commanded by a DCL procedure, launches the calculation of the movements in BATCH mode which insures at the same time:

- the resetting of the axes of the machine before the calculation
- the manufacturing of the pre shape as soon as we know its dimension
- the manufacturing of the crown at the end of the calculations.

Batch means "hidden".

4.1-2.2 Movements calculation

The program could be interactively used. To avoid any mistake, this calculation is blind to the dentist. After the dentist has accepted the manufacturing, it happens in two steps, first a pre manufacture of the pre shape to get to a state closer to reality, then a specific manufacture of the crown.

4.1-2.3 Intervention

It is possible to stop in emergency, to stop between each tool or when one or the case has been done. The flipping of the piece is used to observe the different stages.

4.1-3 Conclusion

The dentist having defined his prosthesis, the software knowing the volume of the pre shapes indicates which pre shape to place (1, 2 or3) so that the dentist can launch the manufacturing. It frees the post as the process is automatic. Some interventions can help control his work.

4.2 Manufacturing

The manufacturing must be divided, in its study, into two distinct parts which are:

- digital command
- tool machine

If the first element insures the positioning of the brooch, the control of the movement and of the speed (and other things), the second element is an executive organ. In the first case, it will be a question of studying the functioning choice whereas in the second case, it will be more the quality in a larger sense of the execution of the work.

4.2-1 The digital command

4.2-1.1 Definition

As we have summarised previously, a digital command insures the control of the position and of the speed of movement of the mobile parts of the machine. It insures as well a certain number of accessory chores of the manufacturing cycle enabling for example the lubrication and change of tool.

Traditionally, it is composed of:

- an instruction of the programs and their stocking zone
- a system of data treatment and amplification of the movement's command
- a certain number of control of the quality of order's execution organs
- management of the annex program, as the tool change

The digital command receives a manufacturing program under a coded form (APT, CP/M…) completed with specific manufacturing, reference for the control captors and logical signals for the peripherals signals.

It analyses the manufacturing program it receives from EUCLID and organises the values into functional categories (sizes, speed, tools, flipping…). It doesn't have to take into account the manufacturing parameters as they have already been prepared (generation of movement depending on the BEZIERS surfaces respecting the geometrics of the tool). It has to queue them, the thus prepared values so they are executed according to a logical sequence with the data necessary to a good execution.

The first function of the digital command action is the creation of the movement of each tool depending on the known position in space of the tool and the pre shape. This step is realised with EUCLID. The second function of the command, at the CN card level, is the coordination of the axes of the machine to execute the movement addressed to the calculator. After having prepared the data (treatment logic), the program is directed towards the interpolators.

They elaborate the movement the axes will have to follow. Whether we use a spatial linear or circular interpolation, is calculated at each moment the projection of a point running on the axes. This function is insured at the CN by PRODYS card level. The third function, executed here again on a PRODYS card, called of power, is the analogue digital transformation of the data by the variations which address a tension to each engine to rotate their axes, thus moving the tool and the brooch in space.

Next to these movement functions, cohabits a logical step (automate function) treating:

- the piloting of the tool-carrier
- the management of the speed of rotation of the brooches
- the command of the fixation of the brooch
- the security functions of the machine
- the lubrication command

The equipment is composed of a material part and a software part:

- the material is presented as a multiprocessor calculator whose elements are as follow:
    - a central treatment unit with microprocessor which is charged to interpret and realise the different operations (unit of treatment and zone of stock)
    - interface modules which elaborate the logical signals from the axes interfaces
    - an automate processor programmable (logical step)

All of this must communicate by buses. The program is placed on an electronic support or a dead memory PROM-ERROM, programmable and dependant of the central unit.

4.2-1.2 History

CAD's history, that is to say computer assister design, outside BERNARD's pre studies (CECN) in 1982 and DIMNEZ's (Ecole Centrale) at the same time, first goes through a bibliographic optimisation research. Rapidly, we admit that we must reorganise the modelling values at the CAD level (CAD/CAM). We had two possibilities as we wrote in 1982.

"We admit at this moment that the theoretical sizes of a crown are obtained and stocked. To go to the study to the manufacturing part, several methods are possible:

a) in MATRA's EUCLID system, an interface program exists "insuring the automatic transcription of an EUCLID geometry to a labelled geometry "PAT", "COMPACT", "PROMO", … which we still have to choose (DATAVISION). It is possible also, that in the same system, we use an interactive preparing the manufacturing and visualising to control the tools' movements; it is possible to automatically get orders of tool movements.

b) in the CATIA system, the principal is the same: "CAITA", with its third function, is the preparation tool of the manufacturing by digital command of the geometrical elements archived in the database. The preparer in front of the interactive graphic console, describes the movement of the drill or selects the geometrical movements on which the drill will be based. He defines the shape of the tool (spherical, toric, cylindrical) the type of manufacture (3 axes or 5 axes) and the necessary technological data."

After a few tries in MATRA's military manufacturing branch, we decide in November 1982 to call on outside help, that is to say a CNC of ICN system in Chambéry. The principal was to point a group of 400 points spread on 26 levels of cut, that is to say a precision in x, y of 250µ and in z of 500µ. The program was introduced manually from a theoretical tooth modelled in EUCLID on a cassette placed in the ICN "synthesis" console (figure 76). This command was presented at the GARANCIERE in 1983, before being abandoned for MOCN from KUHLMANN for reasons both financial and technical.

From 1984 (January) until November 1985, an extremely thorough study is done with the aim of associating KUHLMANN's micro drill, the FPK8 digital command and the CAM part of EUCLID. Moreover and in parallel, we pushed this German company to develop a specific model for dental surgery. This is how was presented on November 25th 1985 at the ADF, a tool machine capable of realising a crown. To get there, we first had to work on a digitalisation table and manually enter the theoretical teeth's dimensions then to establish an EUCLID/KUHLMANN connection and finally EUCLID's instructions from the digital step instructions and the logical step (figure 77).

From May 1986, we had to abandon totally the KUHLMANN solution for numerous reasons:

- price too high of the micro drill and its command
- no effort from KUHLMANN to go from 2 ½ axes to 3 axes
- scientific communication too difficult

For this reason, we established a complete specifications book and accepted the proposition of ETS LAMBERT. It obliged us to find a new digital command. Accidentally, M. CHIARAMELLA met HENNSON and enabled us to develop a digital command specific to our application (today the PRODYS company) part of the OCE group).

This digital command has three successive evolutions:

- application of the CN PRODYS on KUHLMANN
- creation of a prototype CN on LAMBERT's machine
- incorporation of a compact CN card

4.2-1.3 Generation of digital and logical functions

We have two working steps on the information issued from the external and internal modelling of the prosthesis. The first information is compact and structured by EUCLID when the second will be at CN by PRODYS level.

4.2-1.3.1 EUCLID work for digital command

The prosthesis being known by the computer, all there is left to do, in theory, is manufacture it. However, the necessary treatment to get from modelling of the crown to the generation of the manufacturing commands, brings forward the parameters linked to "PRODYS" digital command's know-how, the fixation mode of the material to be manufactured, the characteristics of the tools used and the manufacturing mode…

The "DIGITAL COMMAND" application has for aim to take in charge the realisation of a dental crown, on a digital command unit, from a tri dimensional shape generated on a CAD system. Firstly, an EUCLID application enables the calculation, in the prosthesis space, of the whole of the tools movements corresponding to the chosen range.

a) Tool movement function (figure 78):

This function insures the generation of tools movements, initial step in the manufacturing process of a crown. When CAD launches this function, there is acquisition of the EUCLID CAM, the extrados, the intrados, the finishing line and the predefined range for each crown.

- <u>the extrados</u> is defined by the figure of the spline B channels describers constituting each crown
- <u>the intrados</u> given under a polyedric shape (surface) where each point being on the outside of the finishing line is brought back to an inferior altitude at the z minimum of this finishing line
- <u>the finishing line</u> which is presented in the shape of a broken line. This final manufacturing uses a sketch of 0.5mm by 1.5mm high, a semi finish of about 12 movements and the last movement on the tangent line
- <u>the furrows:</u> they are underlined as we have described in CAD at a constant depth for each pass. It was also possible to create sketches by progressive over manufacturing and generate furrows and facets at different depths.

SECTION NUMERO 6 SUREPAISSEURE 0.00

POINT NUMERO	1	X =	1.43268	Y =	0.09771	Z =	-0.32460
POINT NUMERO	2	X =	1.47259	Y =	-0.03849	Z =	-0.32482
POINT NUMERO	3	X =	1.54654	Y =	-0.14095	Z =	-0.32451
POINT NUMERO	4	X =	1.64498	Y =	-0.20727	Z =	-0.32460
POINT NUMERO	5	X =	1.75757	Y =	-0.25679	Z =	-0.32460
POINT NUMERO	6	X =	1.87423	Y =	-0.25033	Z =	-0.32460
POINT NUMERO	7	X =	1.98557	Y =	-0.19006	Z =	-0.32460
POINT NUMERO	8	X =	2.08213	Y =	-0.11948	Z =	-0.32460
POINT NUMERO	9	X =	2.15527	Y =	-0.02340	Z =	-0.32480
POINT NUMERO	10	X =	2.19637	Y =	0.09211	Z =	-0.32481
POINT NUMERO	11	X =	2.19768	Y =	0.21962	Z =	-0.32481
POINT NUMERO	12	X =	2.15215	Y =	0.35027	Z =	-0.32462
POINT NUMERO	13	X =	2.04019	Y =	0.50696	Z =	-0.32460
POINT NUMERO	14	X =	[illegible]	Y =	0.61991	Z =	-0.32460
POINT NUMERO	15	X =	1.82272	Y =	0.68935	Z =	-0.32462
POINT NUMERO	16	X =	1.72403	Y =	0.72258	Z =	-0.32481
POINT NUMERO	17	X =	1.63927	Y =	0.72591	Z =	-0.32480
POINT NUMERO	18	X =	1.56339	Y =	0.70243	Z =	-0.32460
POINT NUMERO	19	X =	1.50010	Y =	0.65731	Z =	-0.32480
POINT NUMERO	20	X =	1.45169	Y =	0.57733	Z =	-0.32480
POINT NUMERO	21	X =	1.42147	Y =	0.45562	Z =	-0.32462
POINT NUMERO	22	X =	1.41305	Y =	0.29549	Z =	-0.32460

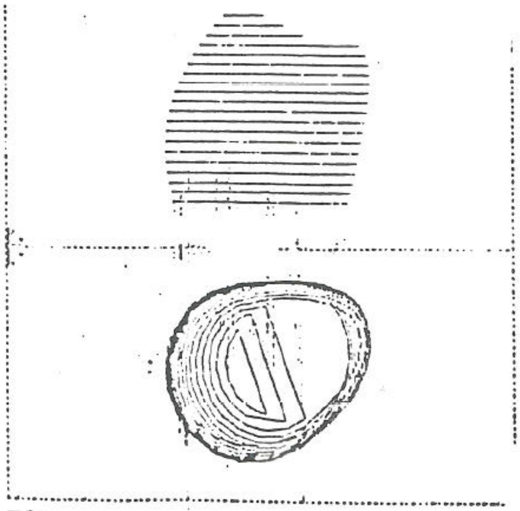


Figure 76

GARANCIERE 1983 (M.O.)

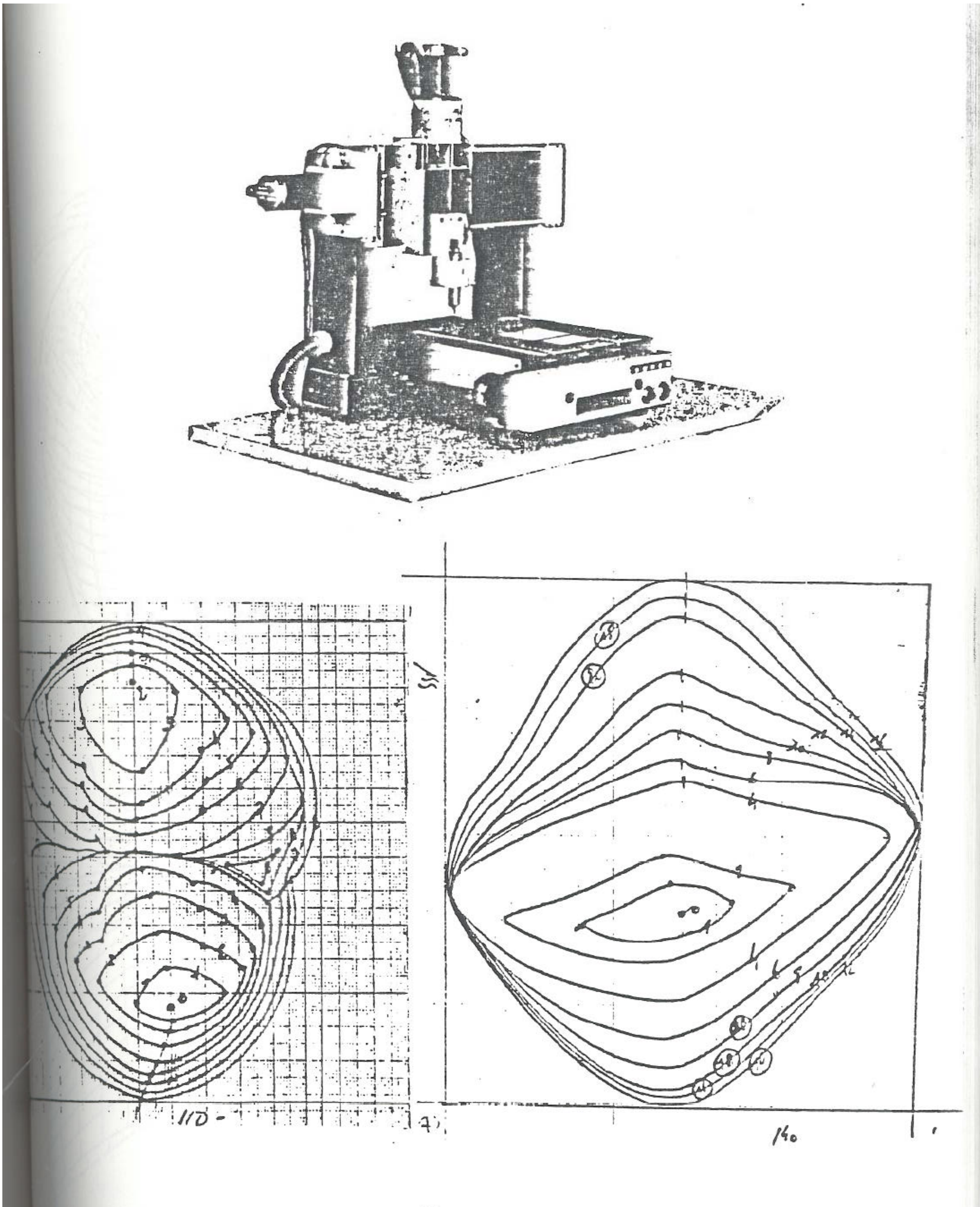


Figure 77

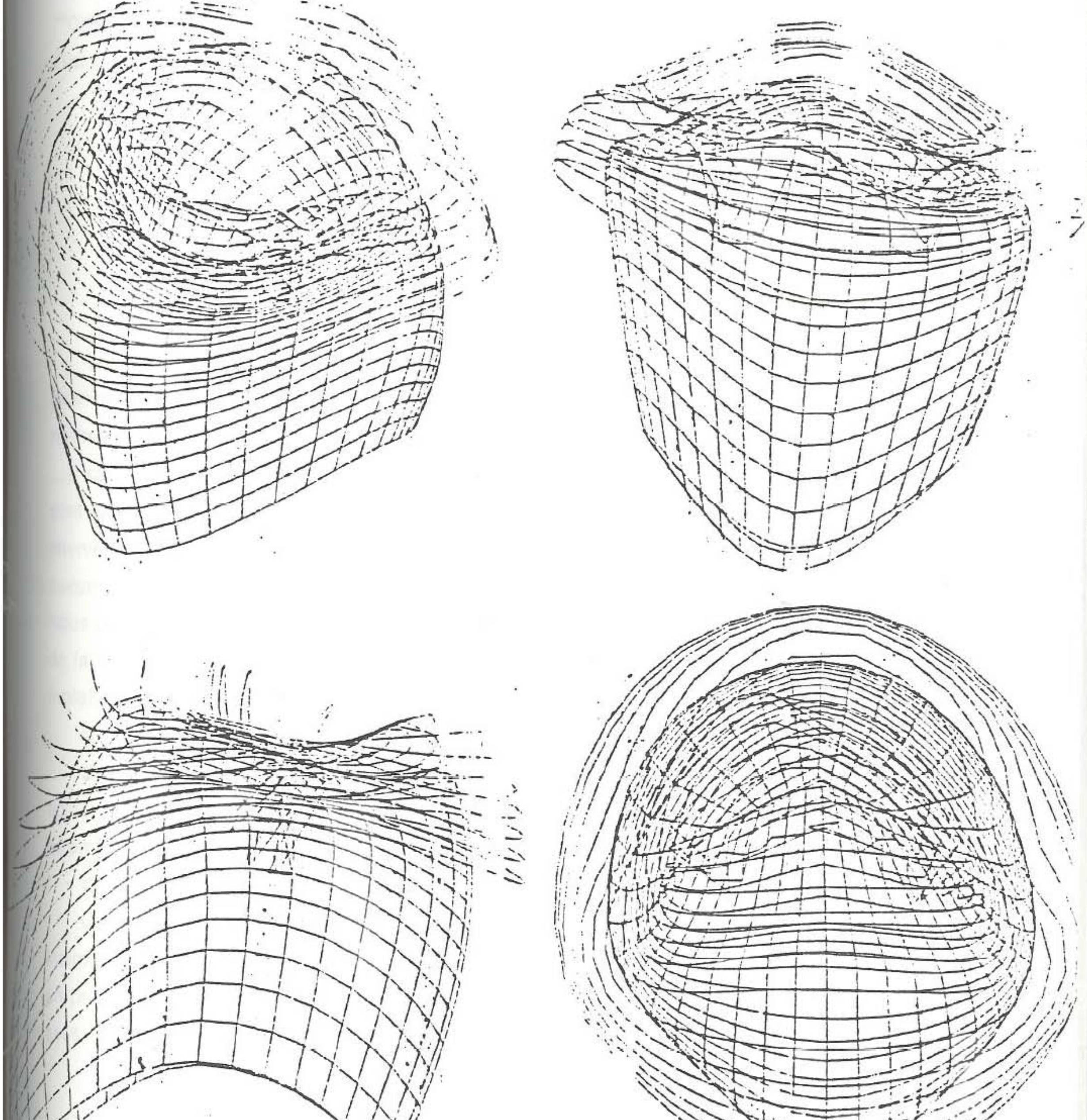


Figure 78

b) Gamm function

Even though they are totally transparent to the user, let's remind the principals of the determination of the Gamm (symbols). The name entered by the user when the manufacturing starts must correspond to a "DAT" fie which is found in the "DK$BIBLI" directory. This file contains all the code names of all the tools to use during the manufacturing of a crown. The first letter of the code indicates the nature of the considered tool:

- 'P' for pointing tool
- 'F' for drill
- 'C' for cylindrical drill (or conic)
- 'S' for spherical drill
- 'T' for toric drill
- 'I' for pointy conic drill (i.e. "flame")
- 'O' for hole rectification knife

The last three alpha-numeric characters of the code are different. We will take for example the diameter of the tool; thus a C400 code designates a cylindrical drill of 4mm diameter (figure 79). The nature of each tool (spherical, cylindrical, …), its own function (bowl manufacturing, intrados manufacturing, …) as well as the order in which the tools are used are unchangeable parameters on which the user can't and mustn't tried to apply change or suppression or addition of a new tool in the initially defined range. We give as annexed figures the example of the calculation of a manufacturing movement for a premolar. In the same way, we can see the manufacturing of a crown or the occlusal surface of a molar 'figure 80, 81, 82).

c) GEO function

After this double action, movement and gamm, is the GEO function which generates an extension sequential file where the movements of each tool are stocked. This file is automatically created and used as a data file for the post-processor.

d) Post-processor function

This program does a translation of the GEO file in DAT file directly interpretable by the digital command unit and addressed to an asynchronic line thanks to a pilot program. The file is still sequential but only understands data in the "character" form (ASC III).

4.2-1.3.2 PRODYS card work

The PRODYS step has for aim to transcribe into analogue the orders from thepost-processor. It is divided in one level called "RL 1" with an exit/RS 232 module and a CN programming in 6809 assembler.

EXEMPLE DE FICHIER DE GAMME

Rapport Odontologique Confidentiel

```
-----------------------------------------------------------------------
 OUTIL !          NATURE          ! DIAMETRE !       FONCTION        ! No !
-----------------------------------------------------------------------
P001   ! OUTIL A POINTER          !          !                       !  1 !
-----------------------------------------------------------------------
F650   ! FORET                    ! D= 650   ! AVANT-TROU            !  2 !
-----------------------------------------------------------------------
C400   ! FRAISE CYLINDRIQUE       ! D= 400   ! EBAUCHE               !  3 !
   33  ! Altitude du voile en % de ZMAX-ZMIN a partir de ZMIN       !    !
  100  ! Epaisseur du voile      !          !                       !    !
  500  ! Dx de degagement: distance de l'avant-trou a l'ebauche     !    !
-----------------------------------------------------------------------
S500   ! FRAISE SPHERIQUE         ! D= 500   ! EBAUCHE / FINITION    !  4 !
   10  ! Nombre de passes 3 axes sur le bol au dessus du voile      !    !
    5  ! Nombre de passes 2 axes sur le bol au dessus du voile      !    !
    5  ! Nombre de passes 3 axes sur la surface occlusale           !    !
    5  ! Nombre de passes 3 axes sur le bol en dessous du voile     !    !
    5  ! Nombre de passes 2 axes sur le bol en dessous du voile     !    !
-----------------------------------------------------------------------
S140   ! FRAISE SPHERIQUE         ! D= 140   ! FINITION OCCLUSALE    !  5 !
   10  ! Nombre de passes 3 axes sur la surface occlusale           !    !
-----------------------------------------------------------------------
T001   ! OUTIL POINTU             ! D=   0   ! FINITION DU SILLON    !  6 !
-----------------------------------------------------------------------
T400   ! FRAISE TORIQUE           ! D= 400   ! FINITION DU BOL       !  7 !
    5  ! Nombre de passes 2 axes sur le bol au dessus du voile      !    !
    5  ! Nombre de passes 2 axes sur le bol en dessous du voile     !    !
-----------------------------------------------------------------------
P002   ! OUTIL A POINTER          !          !                       !  8 !
-----------------------------------------------------------------------
F200   ! FORET                    ! D= 200   ! AVANT-TROU  INTRADOS  !  9 !
-----------------------------------------------------------------------
D200   ! COUTEAU                  ! D= 200   ! FOND INTRADOS         ! 10 !
-----------------------------------------------------------------------
C142   ! FRAISE CONIQUE           ! D= 142   ! USINAGE INTRADOS      ! 11 !
   50  ! Nombre de passes 2 axes d'usinage de l'intrados            !    !
-----------------------------------------------------------------------
S230   ! FRAISE SPHERIQUE         ! D= 230   ! DEGAGEMENT FINAL      ! 12 !
    5  ! Nombre de passes 2 axes de degagement de la couronne       !    !
  100  ! Largeur des deux ergots finaux !                           !    !
-----------------------------------------------------------------------

FORET DE DIAMETRE 200
-----------------------------------------------------------------------
  200    ! DIAMETRE
 1526    ! HAUTEUR DE MONTAGE DANS LA BROCHE.
   50    ! VITESSE D'AVANCE
   30    ! VITESSE DE COUPE


COUTEAU DE DIAMETRE 200
-----------------------------------------------------------------------
 2065    ! HAUTEUR DE MONTAGE DANS LA BROCHE
   50    ! VITESSE D'AVANCE
   30    ! VITESSE DE COUPE


FRAISE CONIQUE DE DIAMETRE 142
-----------------------------------------------------------------------
  142    ! DIAMETRE
 1766    ! HAUTEUR DE MONTAGE DANS LA BROCHE
   50    ! VITESSE D'AVANCE
   30    ! VITESSE DE COUPE


FRAISE SPHERIQUE DE DIAMETRE 230
-----------------------------------------------------------------------
  230    ! DIAMETRE
    0    ! HAUTEUR DE MONTAGE DANS LA BROCHE
   50    ! VITESSE D'AVANCE
   30    ! VITESSE DE COUPE
```

Figure 79

LA GAMME D'OUTILS

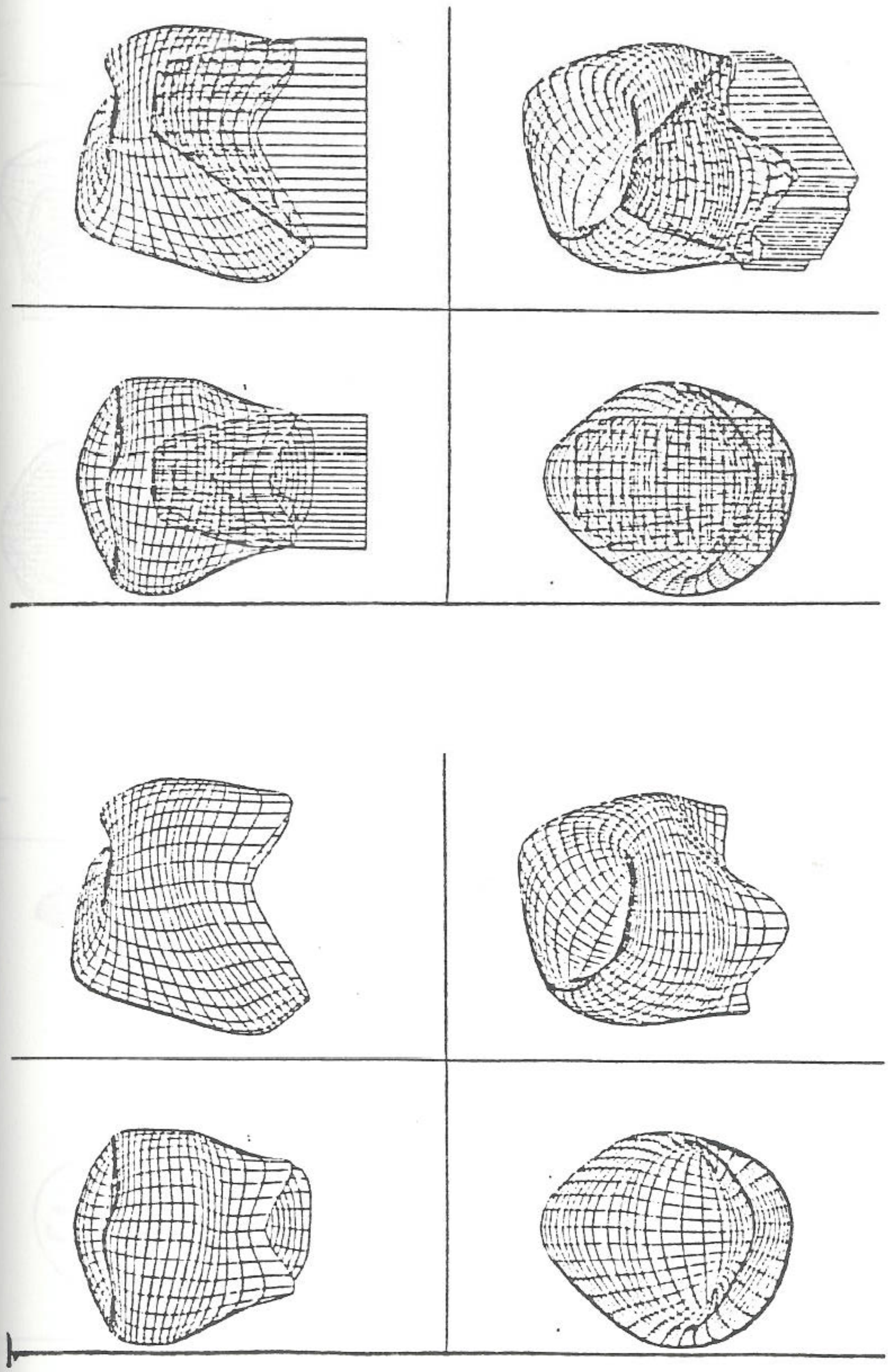


Figure 80

TRAJETS SUR PM (Intrados)

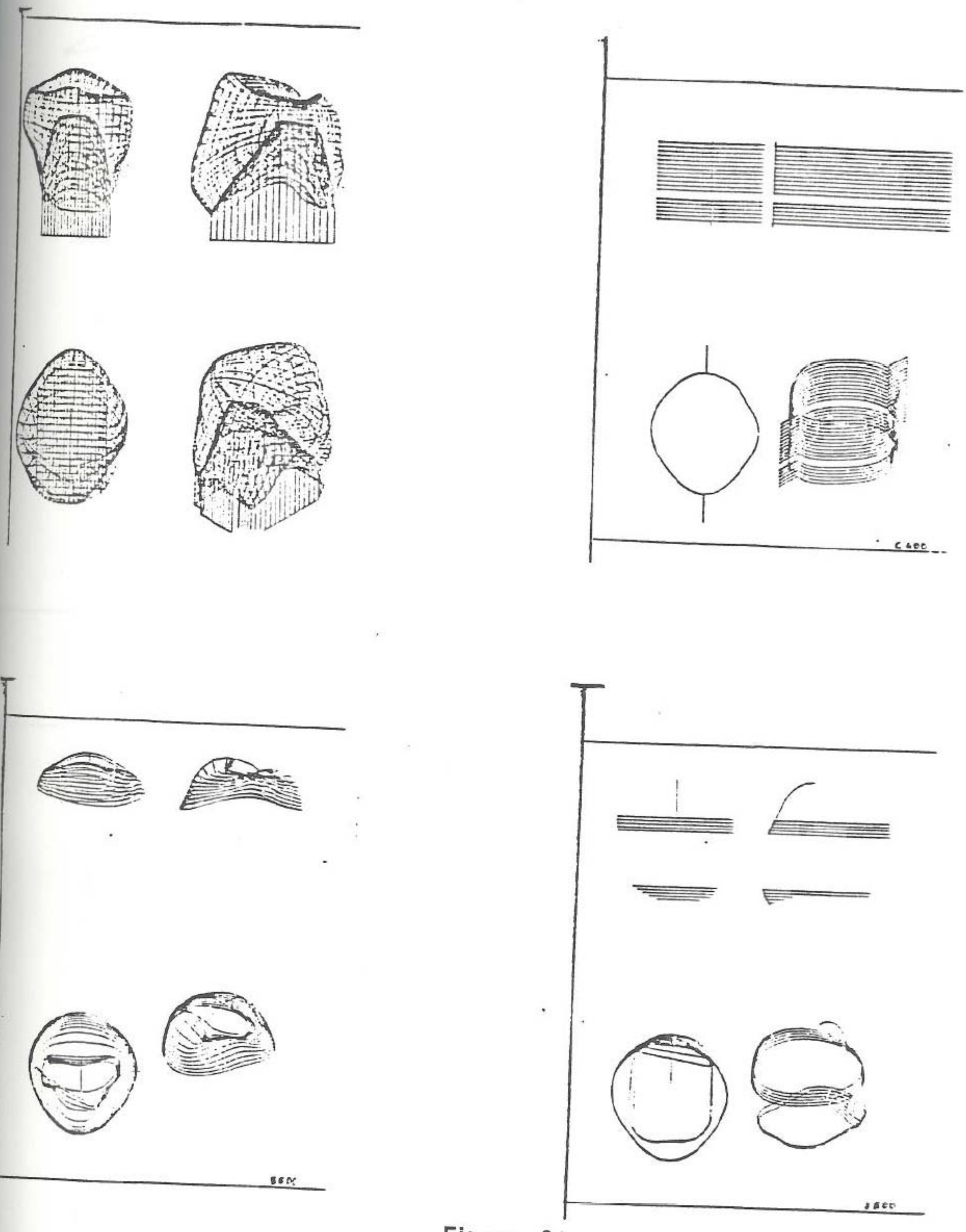


Figure 81

TRAJETS SUR PM (Extrados)

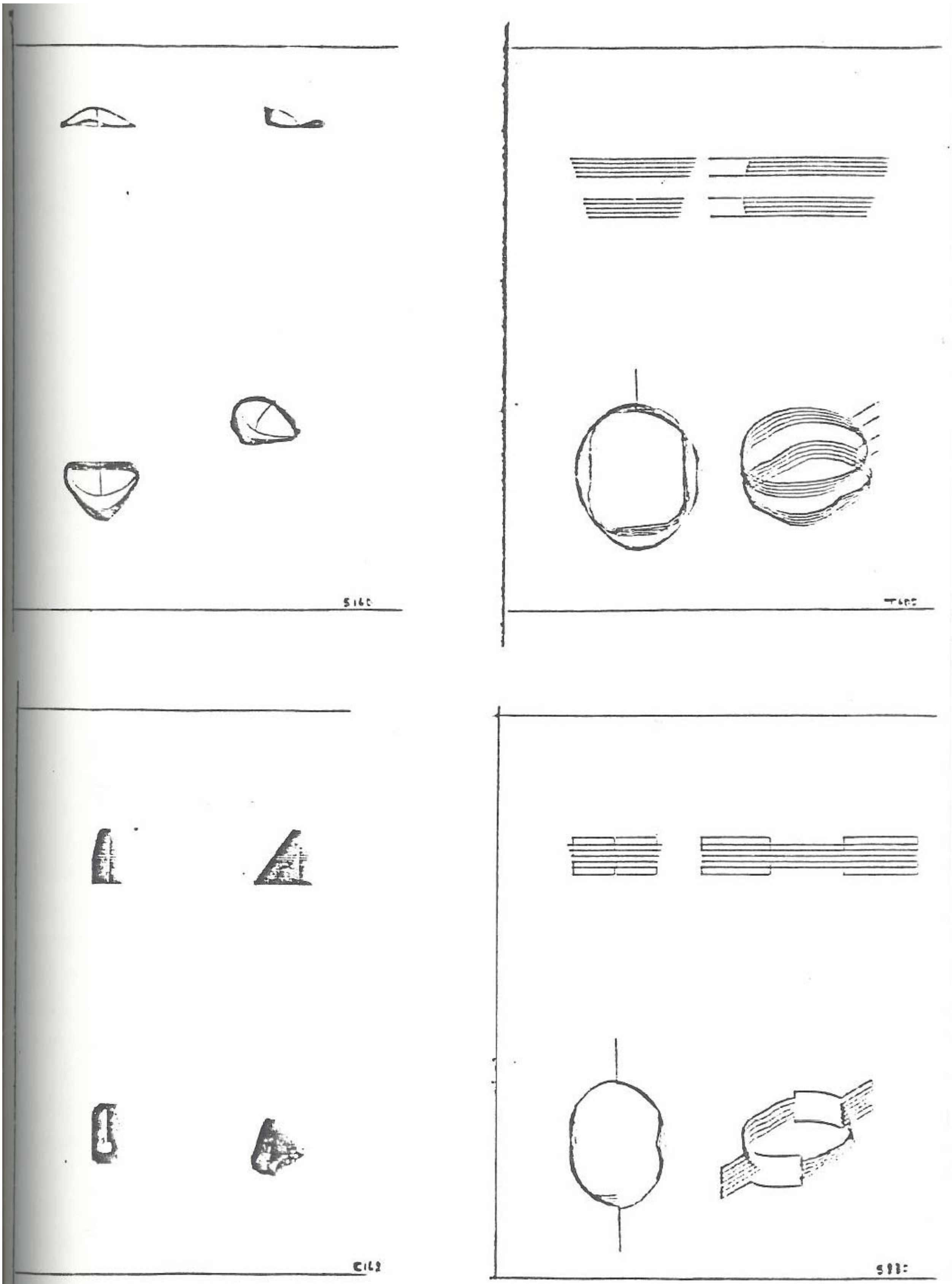


Figure B2

TRAJETS SUR PM (Extrados)

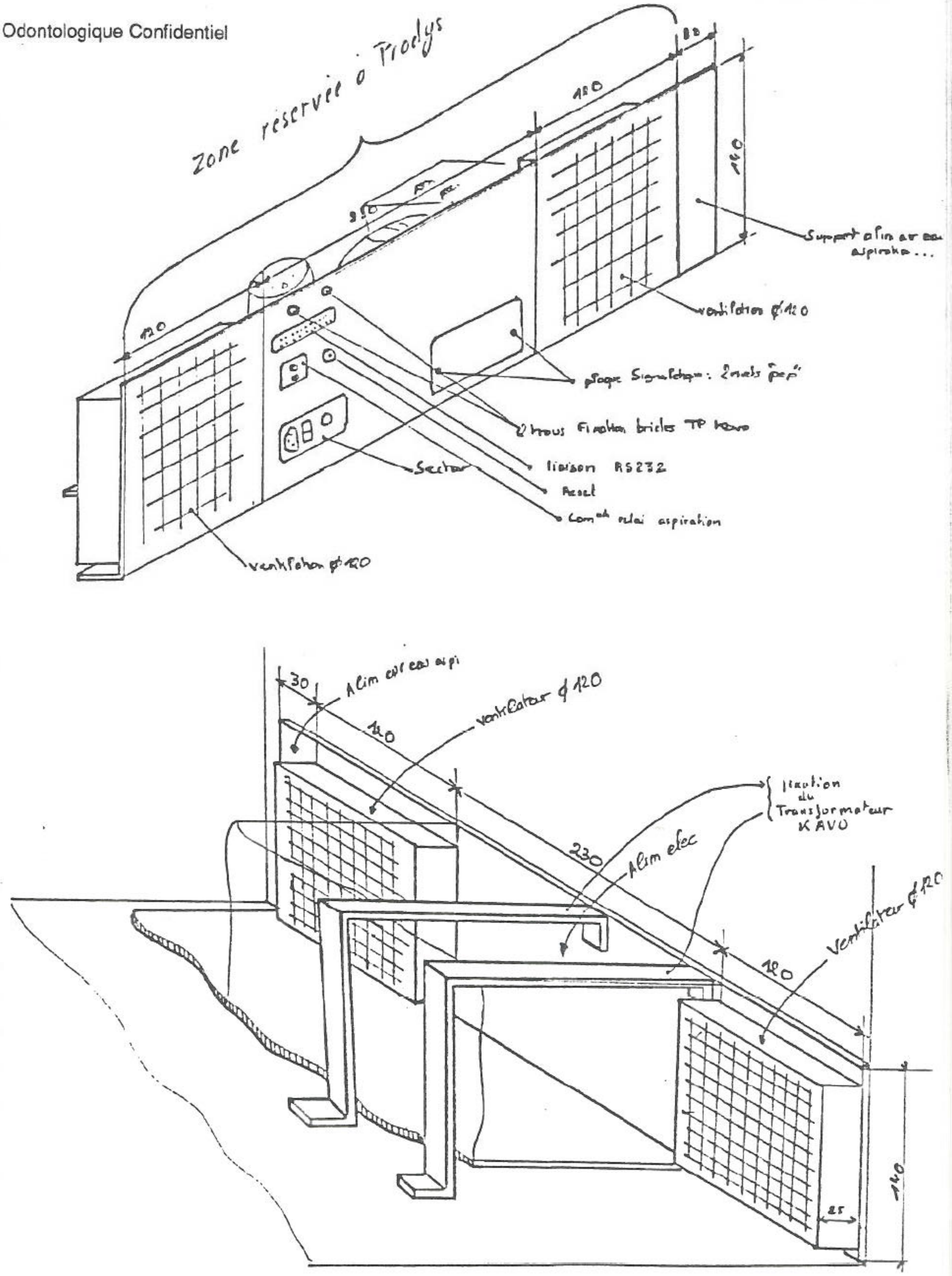


Figure 83

ZONES DE CARTES PRODYS ET KAVO

The RL 1 step is composed of 5 modules which can only work separately. We find the interpolation function, the tool change function, the flipping function, the setting function and the E/S function.

After exiting the interface system, there is an RS 232 link leading to an order interpreter.

The CN step is successively composed of:

- orders interpreter
- memorisation
- orders executer giving on an interpolation movement road and a “speed” road
- frequency generator (D/A conversion)
- amplifier on engine

and the Kavo card.

The brooch of the tool machine must be linked to the PRODYS card by the intermediary of the frequency changer to control, from the PRODYS car, the speed of the engine in synchronisation with the brooch (the KAVO card provides the 12V – 100mA energy).

Both cards are integrated to the tool machine (PRODYS and KAVO) (figure 83).

4.2-2 The tool machine

4.2-2.1 Definition

A digital command tool machine is a mechanical ensemble where each of the mobile parts is under the control of a digital calculator. It can only function if previously the manufacturing program has been correctly established. A tool machine, in dental prosthesis, is composed of three axes (x, y and z) and of a fourth to flip the piece to enable the manufacturing of the intrados. Moreover, other engines are use to move the tool magazine. Each axis can be butted and the tools are checked before being used on a micro sensor. The unit is composed of axes movers (engines), links and slides, position sensors, movement axes and a brooch.

a) there are 5 engines (three axes, one for flipping and one for the tools magazine). They are step by step engines. To avoid shakes we interpose between the power command and the engine a frequency variation. This engine works in all or nothing, for each inflexion (variable frequency) a rotor constituted of a magnet is orientated by a giant stator creating a field depending on the courant it is receiving. The engines can have up to 800 steps per round and their speed depends on the commutation of the spools frequency.

b) movers and slides: under the form of marbles screws (marbles along a never ending screw), they enable a transmission of the engine's movement to the unit's axes. This avoids shaking and prejudicial rubbing, a good functioning of the engine step by step which has a low torque.

c) the axes spread in space according to the Cartesian marking , there are four in the HENNSON unit. Three axes x, y and z are movements leading to the movement of the drill around the tooth and a fourth axis insures the rotation of the pre shape (called auxiliary rotation movement).

d) the annex functions for the lubrication and the evacuation insure a good realisation of the prosthetic piece.

4.2-2.2 History

Numerous drills have been tried, before was decided by HENNSON the construction of a specific machine. In 1983 the work started on the MUTAN 2000 by ETECMA. As we define it in our article in 1985, this machine has the following characteristics (figure 84):

- course 150 x 200 x 100 mm
- precision 2, Card 400: 25µ
- brooch speed: 1 to 10 for an engine power of 0.75Kw and a cylindrical drill of 4.5mm diameter

During the same period, after the GARANCIERE where we have presented ou study with the MUTAN 2000, we had met several manufacturers:

- CORTINI L 303 with its micro digital command and its 4 servomotor axes (abandoned for difficulties we had to communicate with Italy)
- The NEW HERMES CONCEPT 2000 unfortunately 2 axes, essentially an engraving machine
- The LIMOGE, precision too archaic in its conception
- The KUHLMANN

We chose the last one in January 1984 without knowing exactly its performances. To know better the qualities of this machine, we decided after a journey to Germany to buy the 20T with its digital command ITT 3030. This machine uses a KAVO brooch (which we still use) with a rotation of 15 000 to 60 000t/m, advancing speed of 80MM/sec, working field of 400 x 400 mm and a 20µ resolution. This machine has enabled us to work on the first manufacturing of a premolar during the 1985 summer (reception in April 1985). In September 1985, we received the definitive dental model or "20T", a lot more compact which enabled us to do the ADF demonstrations in Chambéry, Luxembourg and Marseille. Even though it was rather satisfying, we abandoned it because:

- it was too expensive

- it worked with 2 12 axes and the third was complex to add (digital command level)
- the contacts in Germany were often difficult

For these reasons, in January 1986, we decided to manufacture a specifically dental unit with ETS LAMBERT. From this date HENNSON only had one subcontractor. (5 av. Duchesne – 26102 VALENCE).

4.2-2.3 Dental tool machine

We can divide the unit into several parts:

- the mechanical part
- the hood
- the engines
- the brooch
- the aspiration system
- the lubrication system
- the utilisation mode

4.2-2.3.1 Mechanical part

a) digitalised axes:

Three axes are materialised as follows:

- horizontal x table, longitudinal 130mm
- vertical y table, longitudinal 80mm
- horizontal z table, transversal 70mm

The tables are guided by crossed rolls tracks, size 3, type SHNEEBERGER. They are commanded by marble screws with rectified fillets with nuts of 10mm diameter.

b) a material holder (figure 86, 87)

There are three pre shapes defined in their geometry (4 at the start). Two coaxial clips manually manoeuvred have the function of positioning and securing the pre shape.

c) Two fixed dolls

A left motor doll representing the fourth motorised axis by an indexer of step by step engine type identical to the axes' engines. A free doll on the right.

d) A tool holder (figure 88)

It is composed of a removable disc which has 12 manufacturing tools with characteristics defined later and an indexer step by step engine identical to the axes' engine.

This tool holder presents a hole for holding the tool in position, in front the brooch.

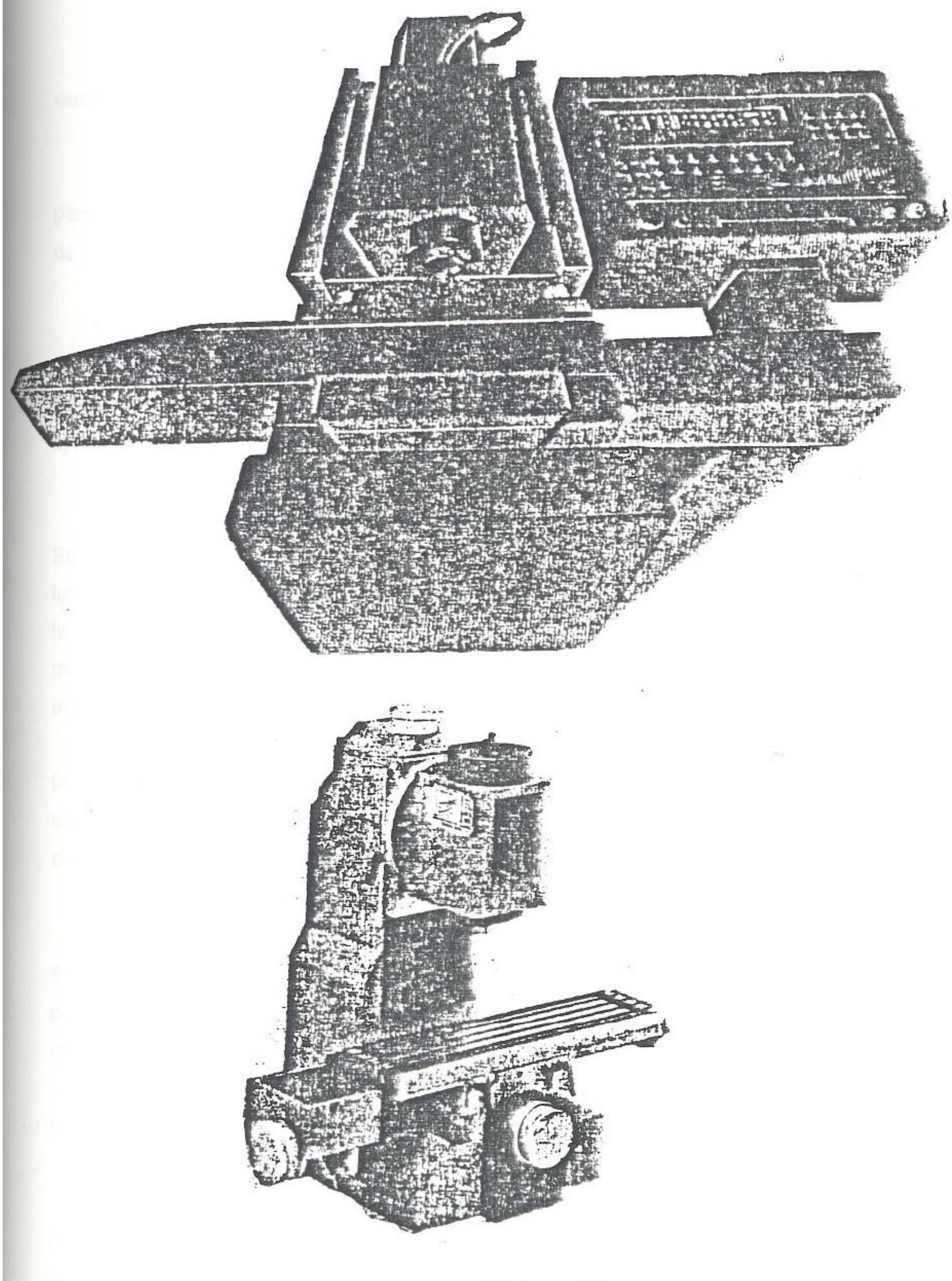


Figure 84

MACHINE-OUTIL ETECMA ET CORTINI

e) The unit's engine mounting (figure85)

Moulded piece and very rigid (heavy) which insures the reach of mechanical, electrical and digital command parts.

f) A median plan with bellow

It enables the partitioning of the unit between the active part (manufacturing, tool use) and the engine and digital command part. It enables the protection to material projections of the precision part.

g) Electrobrooch (figure 89)

We have kept KAVO's 4051 brooch with tool capture and automatic change (pneumatic) of 100W. It can function up to 5000 hours

h) Lubrication

A triple study has been led to determine the most optimal lubrication solution. Firstly, specifications defining the reason for this lubrication were done. This led to the following observations. The manufacturing of the new material destined to the dental CAD/CAM necessitates lubrication in order to get the best cut and minimum effort, a better longevity of the tool, cooling of the tool and of the material, a better state of the surface, evacuation of the chips and the calories.

To insure this lubrication, we have devised a system of pulverisation of liquid air, to optimise the cutting conditions and the consumption. This lubrication is composed of two parts: a liquid and air pulverisation and a system of automatic lubrication liquid alimentation.

i) Pulverisation

Two concentric hoses form the pulverisation base. This base is fixed on the brooch's nose in order to insure permanent lubrication of the tool/piece contact point. This pulverisation is insured by two concentric hoses and two electro valves. The used pressures are around 1 bar for air and 0,2 bars for liquids.

The hoses' diameters are 3mm external and 2.5mm internal diameter for air and for liquid 1.2mm external and 1mm internal diameter for liquid.

j) Automatic alimentation system

The lubrication liquid is composed of two elements: water and additive (cut oil developed specially for dental CAD/CAM by SPAD). We have tried to automate the functions necessary for the lubrication with a minimum of manual interventions. The functions to be automated:

- mixing both products (for 1 litre of water: concentration 4% additive)
- permanent arrival of the mixture towards the pulverisation system with a permanent pressure

- permanent arrival of water in mixing bowl

The only manual intervention for the practioner is changing the additive flask.

This enables the definition:

For the four prototypes

1) 8% concentration additive
2) 5 L/hour mixture
3) 5 to 6 crowns per day
4) 40 mn pulverisation for one manufacturing cycle of a crown, on average

With these elements, we have a global daily consumption of 25 litres of mixture (23 litres of water and 2 litres of additive). Isn't it more interesting, currently, to forecast a simple tank (25 to 30 litres) under pressure (0.2 to 0.8 bars) to insure the necessary daily lubrication? Every morning, we do the only manual intervention which is filling the tank.

For the series, we have defined the following points:

We can redo other bids invitations for our lubrication system, after a longer trial period, a better knowledge of the lubricant and after a complete determination of all the parameters in a more rigorous way depending on the manufacturing tests (material, lubricant, flow, time, pressure, etc…). SPAD Company has implemented a lubricant corresponding to their material. This obliges this company to know exactly the manufacturing conditions, the cutting speeds and movement speeds and the state of the obtained cuts. After the pre series realised between January and March 1987 (we were obliged to wait for the arrival of the definite material), we have done the correlative trial tests between the state of the surface and the lubricant's composition. The experiments have enabled us to define a product optimising the surface state and limiting the tool's wear. This product has the advantage of being conditioned in 2 litres containers changed at the end of every two weeks for 40 elements.

k) Waste receptacle and aspiration

A chip recuperation device, with opening at the front and closed at the back with a supple rubber enabling the brooch's movements, is installed around both dolls. At its base is an aspiration orifice to drain maximum waste.

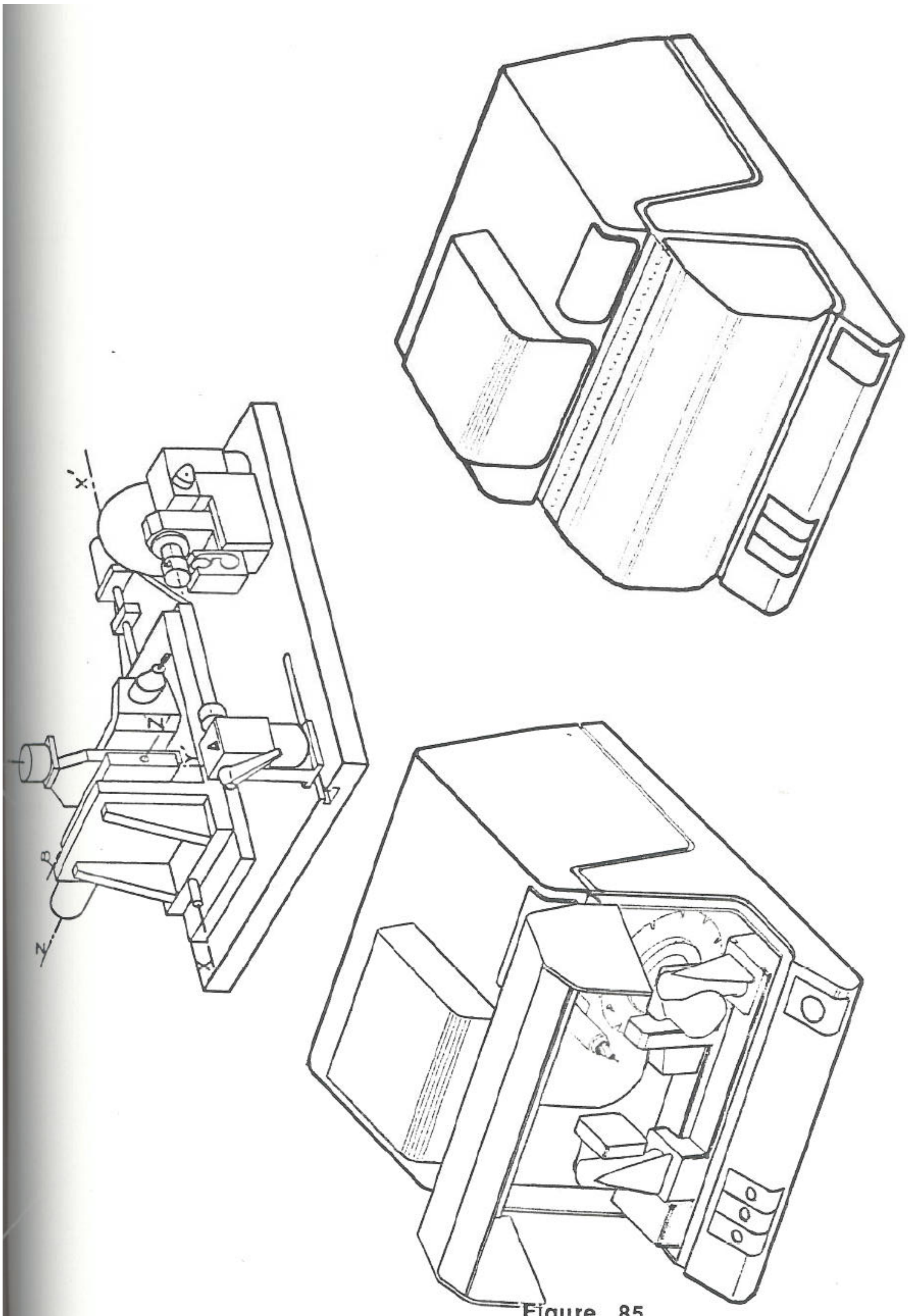


Figure 85

LA PARTIE MECANIQUE

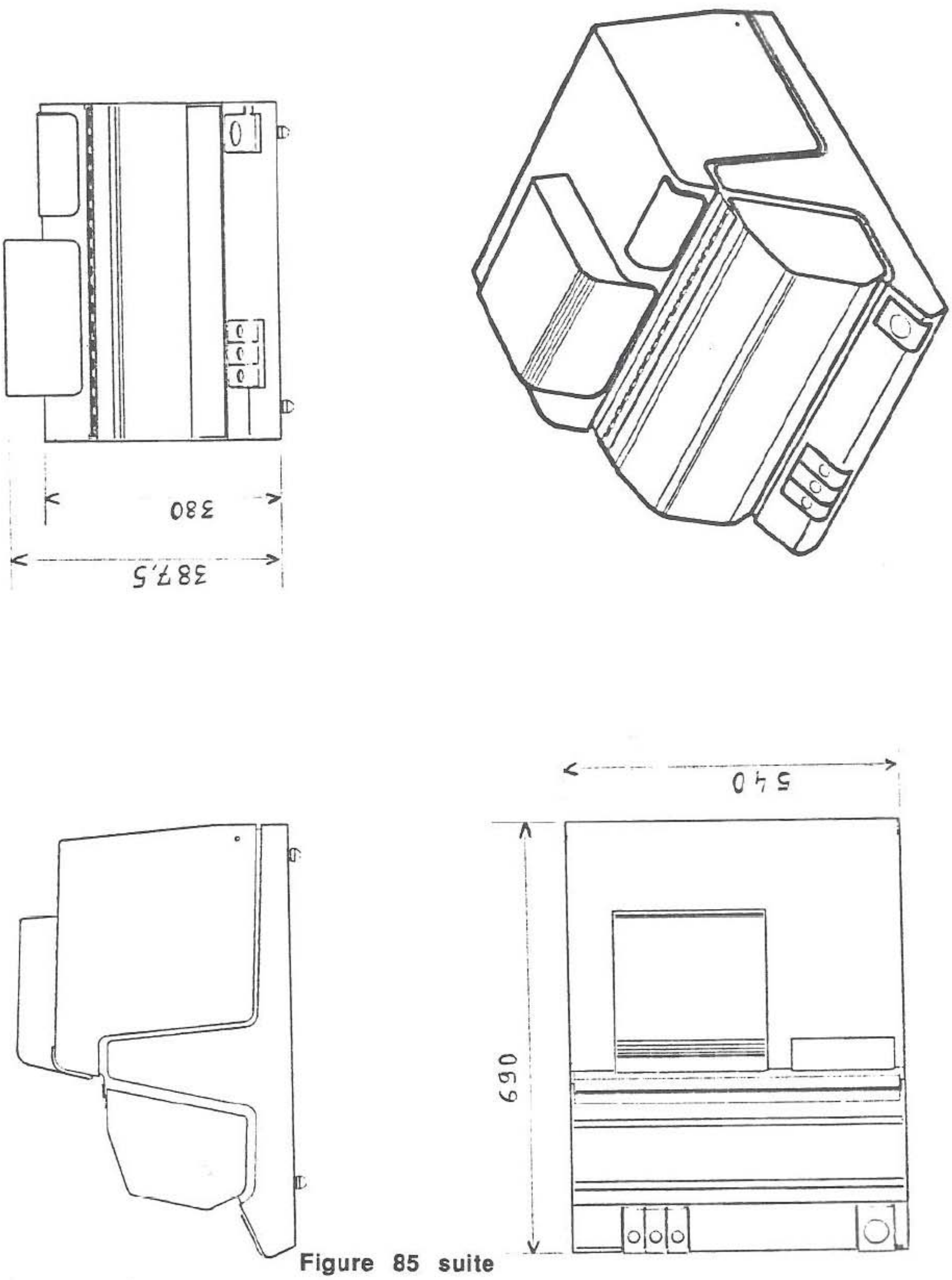


Figure 85 suite

LA PARTIE MECANIQUE

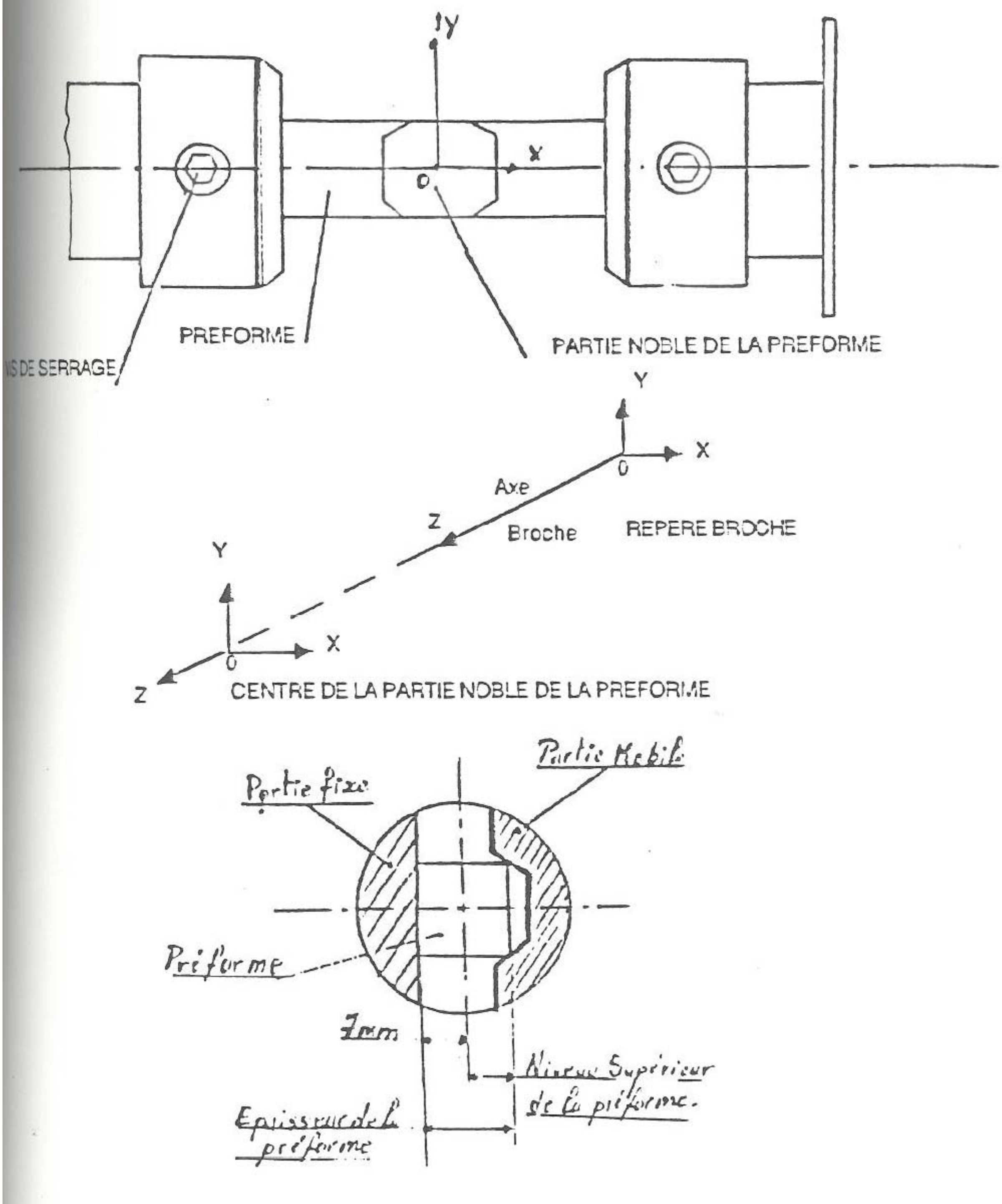


Figure 86

LA PARTIE MATIERE

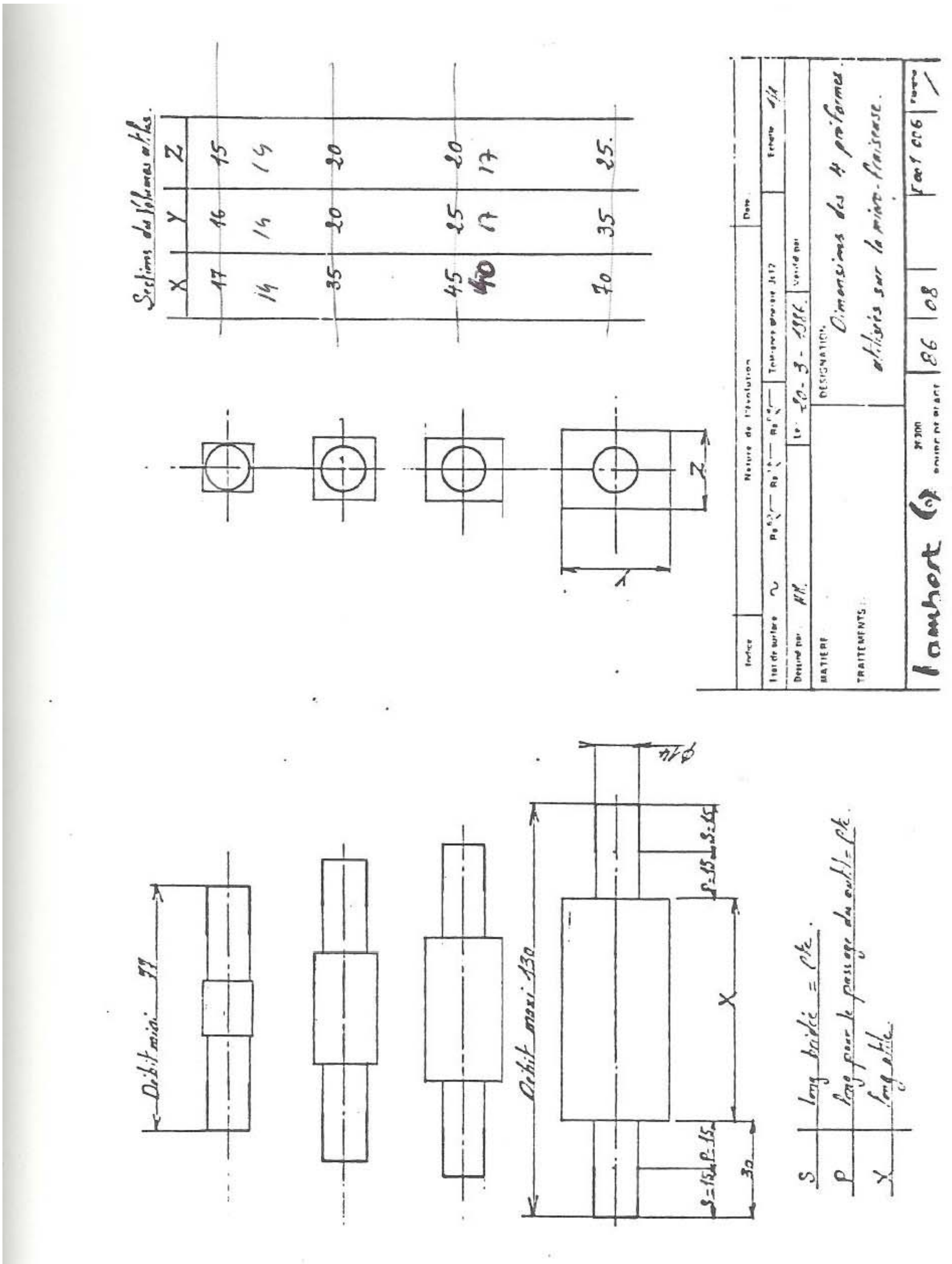


Figure 87

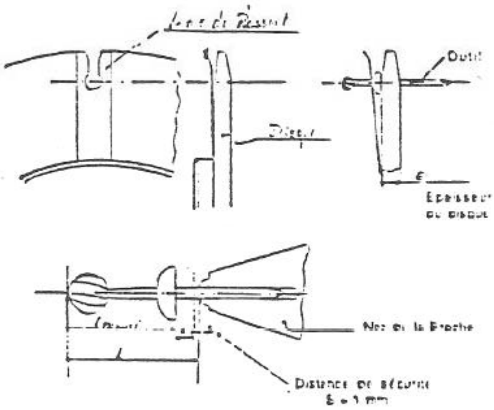
LES PREFORMES
(seules les 3 premières sont retenues)

Station	Code	Diam.	Prof. de passe	LONGUEUR L d'outil	Vitesse d'avance	Vitesse de coupe		Forme
1	C40A	400	25	2200	100	1		Cyl
(1')	C41A	400	25	2200	70	60		Cyl
2	S31A	310	/	1700	80	60		Sph
(2')	S32A	310	/	1700	60	80		Sph
3	S12A	120		1700	80	60		Sph
4	S06A	60	/	1700	80	60		Sph
5	ID1A	/	/	1700	80	80		Pointu
6	T40A	400 120	/	1700	150	1		Torique
7	F15A	150	/	1900	20	100		Forêt
8	C12A	120	/	1700	60	5		Conique

LES UNITEES DE LA MACHINE :

- Base de mesure : 1/100 mm ; 1 mm = 100
- Base de temps : 1/10 s : 0,1 s

EXPLICATIONS DE LA TOUCHE "7"



POSITION DES OUTILS SUR LE DISQUE

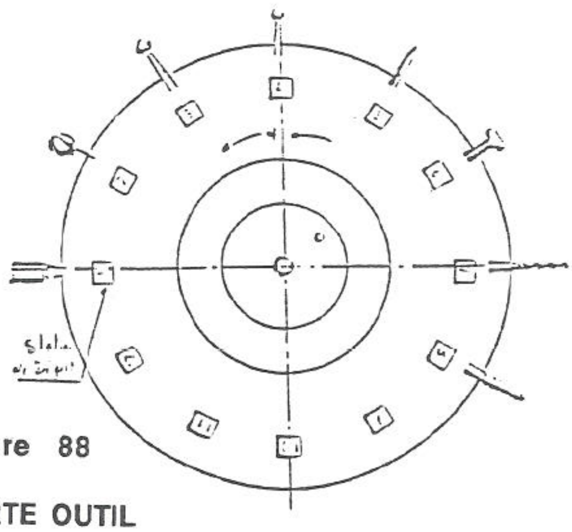


Figure 88

LE PORTE OUTIL

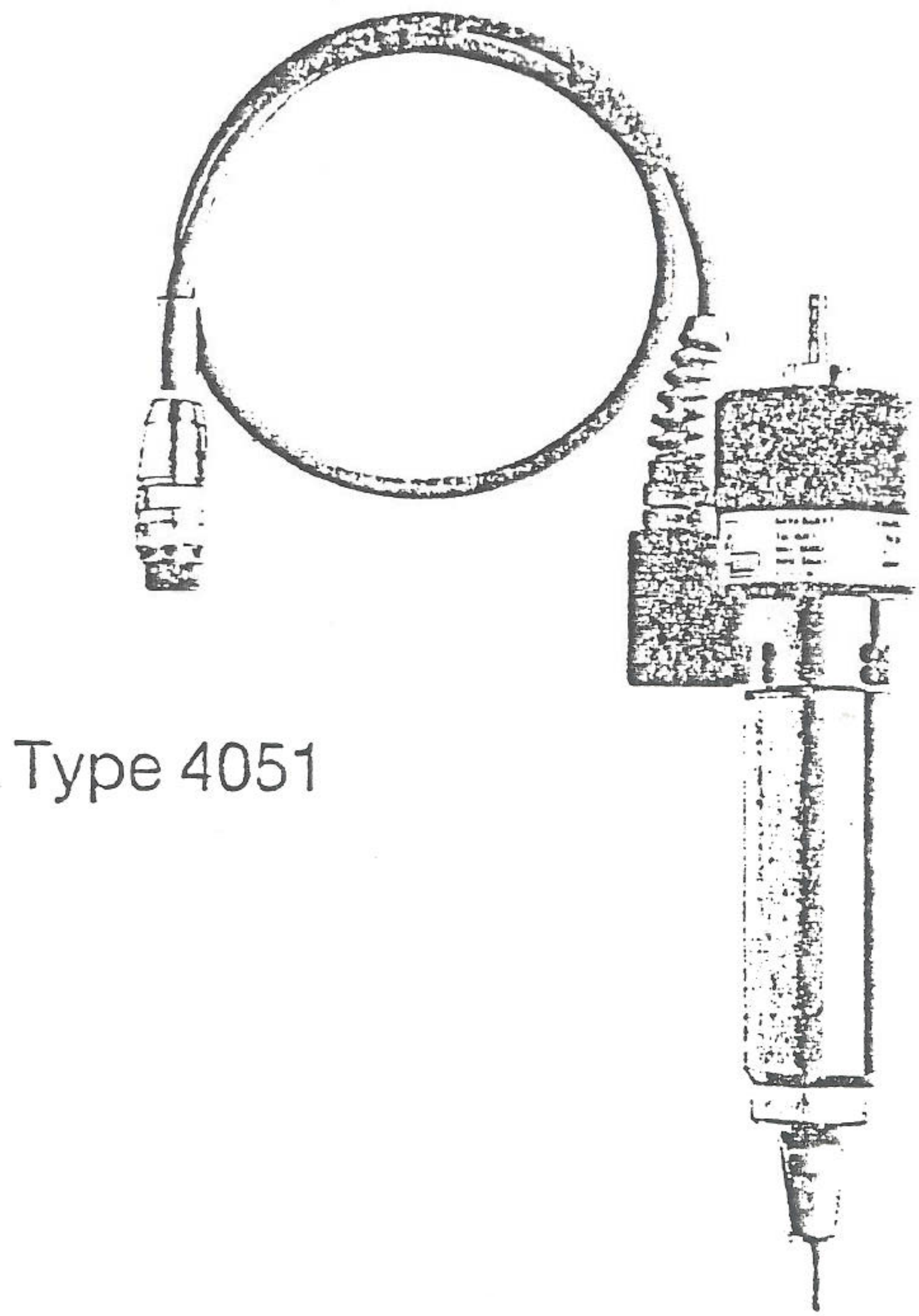


Figure 89

LA BROCHE

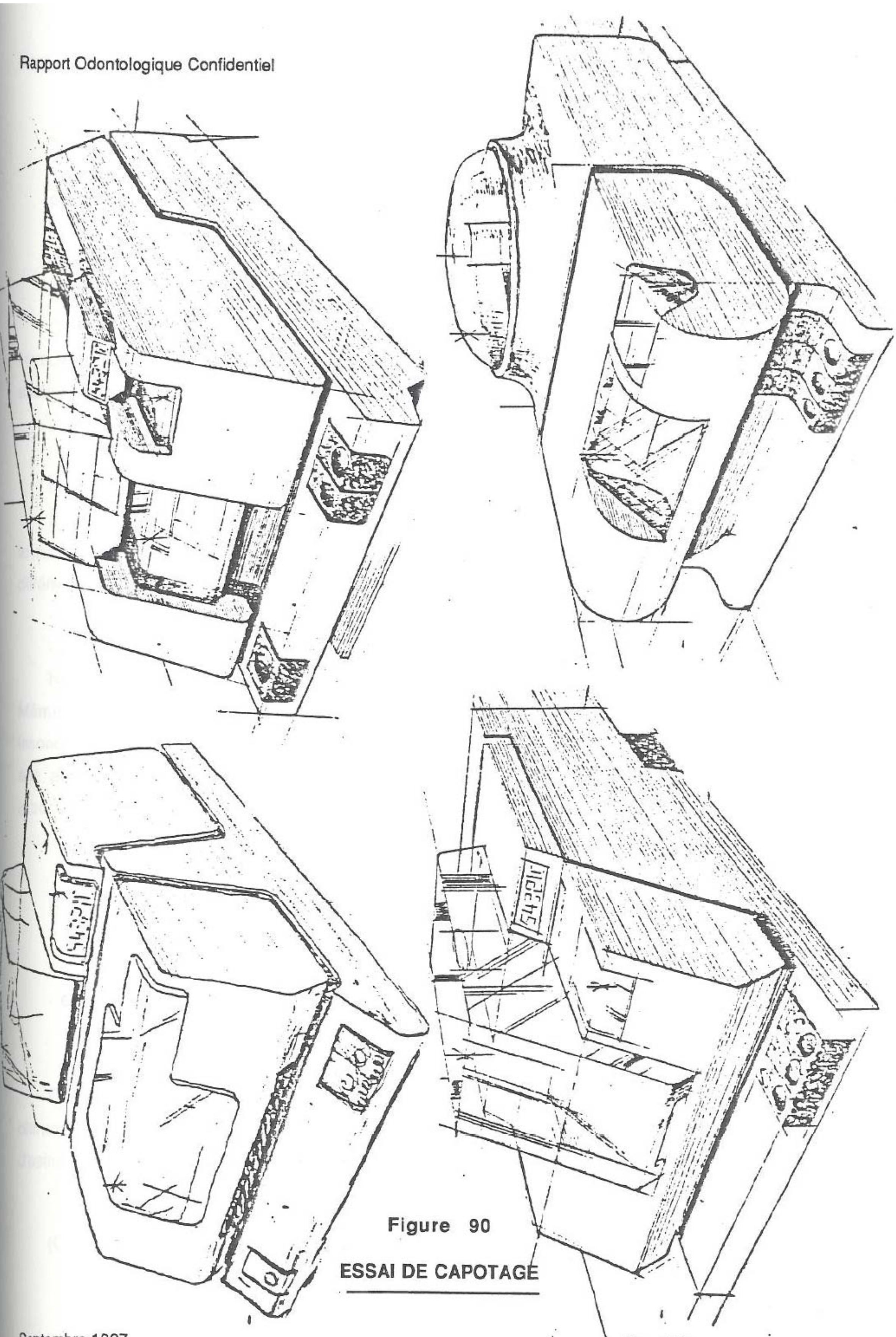


Figure 90

ESSAI DE CAPOTAGE

Evacuation by gravity isn't enough because:

- the evacuation orifice of the receptacle has a diameter of 12mm; moreover, there is a cross to keep the pieces in
- the horizontal hose under the machine facilitates chips depot inside the hose
- lubrication is under pressure and the evacuation flow by gravity through the receptacle orifice is very low

That is why an aspiration of the manufacturing waste is necessary to improve the evacuation and eliminate the depot risk. This aspiration is commanded by the CN to insure a simple and unique function. We use:

- either a classic system installed if it exists in the practice or laboratory
- or in the other case, we install a classic aspiration engine

l) Body

It is the object of an extremely in depth study, in order to integrate the tool machine in a dental practice context (figure 90). Two designers not from the company have offered different solutions for the body.

- ITECA (IZEAUX)
- J M J LEMAIRE

We have chosen the SYNTH solution, replacing the front body by a complete window. Even if the installation of the back fan increases the general functioning noise, a general soundproofing enables the integration of the set in a practice. This soundproofing has also been the subject of a study enabling the integration in a practice or laboratory.

4.2-2.3.2 Electrical part

We successively find:

- digital command + current
- 5 step by step engines
- KAVO electronics

4.2-2.4 Handling

Outside the fixation of the pre shape and the control and replacement of the tools, the dental surgeon has no work to do. The automatic functioning is the manufacturing of a manufacturing file existing in the Microvax under the name:

Nom du fichier ● GEO ; xx

(these files are in the "GEO" directory)

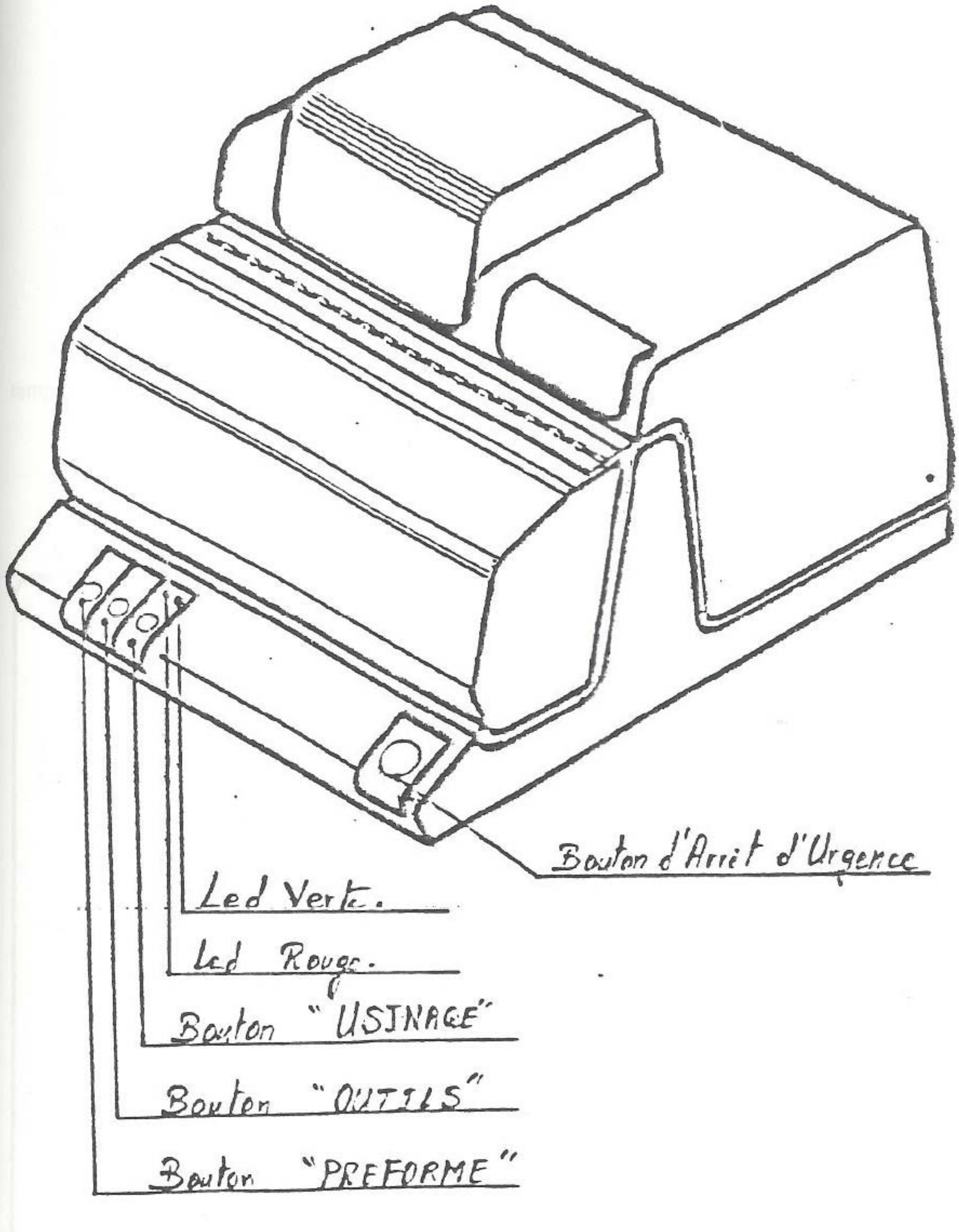


Figure 91

LA BOUTONS D'ACTION DE LA M.O.

We must follow the following protocol (figure 92):

- Check on the tool machine that:
- the brooch is empty and its clip is open
- the receptacle membrane is properly placed and the central ring opposite the brooch
- the disc is correctly placed
- the tools are correctly mounted and in their place on the disc (see next chapter)
- the pre shape is installed correctly and energetically fixed (the noble part opposite the brooch)
- the tightening keys not on the mandrins
- the bodies closed

Note: in the “tools” table, the measuring base is 1/100mm : 1mm = 100 and the time base is 1/10s : 0.1s

The buttons have for function:

- the big red one is emergency stop
- the three little ones are manufacturing, tools and pre shape

The following table summarises the role of each button:

	ON THE TOOL MACHINE
Momentary stops the manufacturing happening, the wait is done at the end of a tool cycle	Press on the MANUFACTURING button (at the end of the tool cycle, if the button was already pressed, the green LED turns off and the red one lights up)
If this momentary stop is asked (red LED lit up, green LED off) It is possible to: - move the tool disc one station per action (counter clockwise)	Activate the TOOLS button
- move the pre shape to see the manufacturing already done 30° per action (rotation towards the outside)	Activate the PRE SHAPE button
Start again and carry on with the current manufacturing	Press the MANUFACTURING button (the disc comes back in place, the pre shape too, the red LED turns off and the green LED lights up and the manufacturing starts again

4.3 Precision of micro drill

4 parameters influence the machine's precision.

- geometrical precision of axes (the relative position of the views with regards to the others (statistical elements))
- precision of the movements (quality of screws, minimum increment, dynamic elements)
- deformations linked to the manufacturing
- temperature

4.3-1 Geometric precision

Linked to the conception, the rigidity of the elements, to the geometrical precision, the machine with its architecture can never pretend to better then ± 5µ in its axes' geometrical positioning, because:

- the conception tolerance of the ± 5µ chariots partly recoverable by a very precise mounting of the machine
- control and alignment means within a 5µ span (to get better, we need huge precautions by comparison to the product, air conditioned white room, …)
- the quality of the materials used which can deform in time, 5µ but recoverable in part by initialisations of the machine

Consequences:

We can't do better than ± 5µ tolerance but this error corresponds to a translation in space of the shape to be reproduced and can in some cases be considered as inexistent.

The final error should be, on the tooth: divided by 2

$$\boxed{\Delta_{\text{géo}} = \pm\ 2{,}5\ \mu m \ \text{ pour une dent}}$$

It's a systematic error.

4.3-2 Movement precision

- **quality of screw**

Two cases are seen to situate this problem:

Positioning error of a screw rectified with regards to a rolled screw.

This error can go from an e_c value (unknown) ± 6µ to an e'_c value ± 52µ for the rolled screw.

The e_c or e'_c values are to be determined by the user as they differ from one screw to another even is the screws are in the same precision class.

Rigorously, the minimum error possible on a screw will be

$\boxed{\Delta_{vis} \quad \pm \quad 2{,}5\ \mu m}$ knowing that vPU = 5µ

The actual error is $\boxed{\pm\ 17{,}5\ \mu m + e_c \ (\text{inconnu})}$

- **Deformation of origins**

The origins definition probe is reproducible at ± 1µ, knowing that it acts on a 33% slope, the reproducibility changes to ± 3µ:

$$\Rightarrow \boxed{\Delta_{origine} \; = \; \pm 3\ \mu m}$$

- **Minimum increment**

Today, it is 6.25µ: size of the 2.5µ screw with one round = 400 steps (200 x 2).

For the series machine, it will be 25µ as the screw's step will be 2mm and one round corresponds to 800 steps (200 x 4).

$$\Rightarrow \boxed{\Delta_{incrément} \; = \; \pm 2{,}5\ \ \mu m}$$

Consequences, the error on precision of the movements will be:

$$\Rightarrow \boxed{\Delta_{mouvement} \; = \; \pm 2{,}5\ \ \mu m}$$

It won't be lower than ± 2.5µ in the current state of things.

4.3-3 Deformation linked to manufacturing

Errors linked to the manufacturing have three origins:

- tool flexion
- machine flexion
- brooch fake rotation round

- **Tool flexion**

For a 500g charge, the tool flexion is:

If L = 18mm

For: Ø 2.35mm F = 10µ

For: Ø 3 mm F = 27µ

- **Machine flexion**

Machine flexions are at a level of 1 to 2µ for a comparable effort.

- **Brooch's fake rotation round**

The brooch's fake rotation round is 0.0.5µ for the KAVO brooch. It can be 0.005µ with a brooch such as Brammer.

Being finished, these different errors should contradict each other or completely cancel each other out. The accumulation of these errors shouldn't be over Δ_{usi}.

$$\Rightarrow \boxed{\Delta_{usi} = \pm 2{,}5\ \mu m}$$

4.3-4 Temperature

It is the parameter that can generate the greatest error on materials such as ZA12 its impact is of 23µ/°C/m so 0.023µ/°C/mm.

Knowing the course of the axes is around 100mm, the generated error is 1.2µ/°C on the course of an axis, that is to say this error, for 1°C, is the same size as the others.

TABLEAU RECAPITULATIF DE L'IMPACTE DES DIFFERENTS PARAMETRES SUR LA PRECISION DE LA MICRO-FRAISEUSE

		Fraiseuses de séries	Fraiseuses prototypes
Précision Géométrique	Conception des Chariots	5 µ	5 µ
	Moyens de contrôle	5 µ	10 µ
	Qualité des matériaux	5 µ	10 µ
	Valeur Globale pour une dent	± 2,5 µ	± 5 µ
Précision des Mouvements	Qualité des vis	± 2,5 µ	± 17,5 µ
	Définition des origines	± 3 µ	± 3 µ
	Incrément minimum	± 2,5 µ	± 6,25 µ
	Valeur Globale	± 8 µ	± 27 µ
Déformation liées à l'usinage	Flexion de l'outil (500 gr)	10 µ	27 µ
	Flexion de la machine (500 gr)	1 à 2 µ	1 à 2 µ
	Faux rond broche	7 µ	20 µ
	Valeur Globale	± 2,5 µ	± 5 µ
Dilatation Thermique	Coefficient de dilatation	0,023µ/°C/mm	0,012µ/°C/mm
	erreur sur la pièce pour une valeur de"x°C"	x = 5 : 10 µ x = 25 : 50 µ	x = 5 x = 25 : 120 µ
A température constante et pour le volume d'une dent, la précision de la Micro-fraiseuse est :		**± 13 µ**	**± 37 µ**

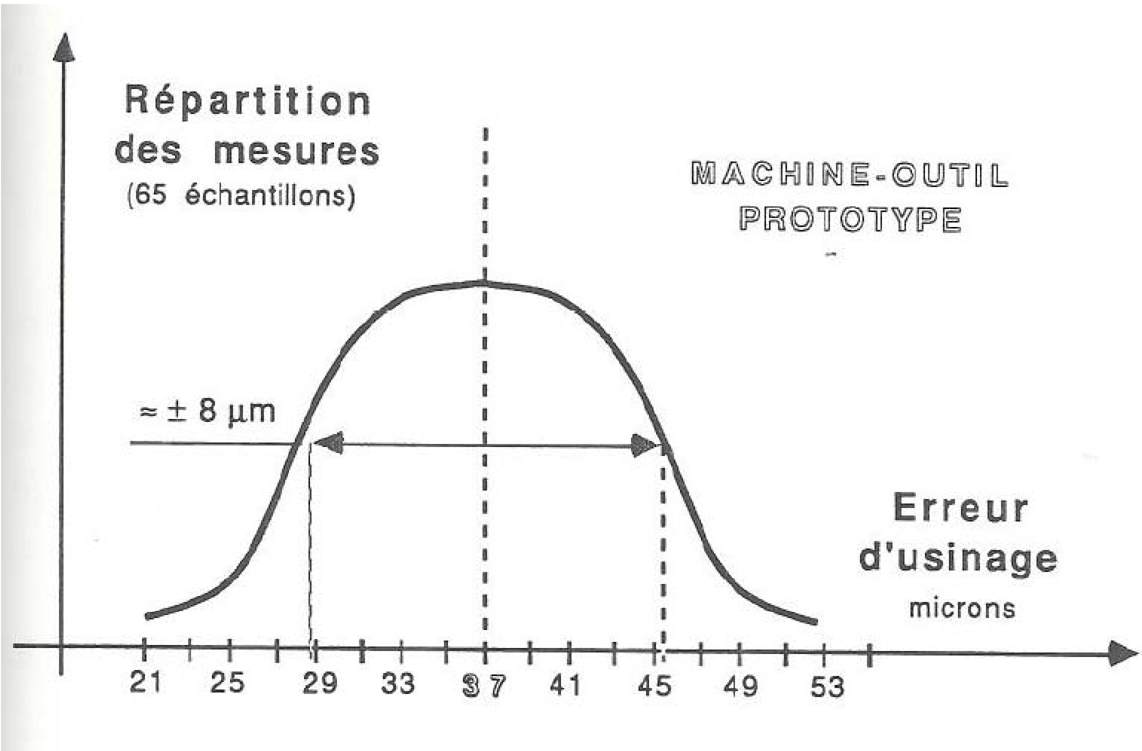
4.4 Conclusion

Outside the instructions about :

- the fixation of the pre shape
- the control and replacement of the tools
- the safety advice
- the interactive functions (4)

The dental surgeon or the prosthodontist have no interventions to make. The handling is extremely simple.

MANUFACTURING ERROR ON THE TOOL MACHINE



5-TOOLS

5.1 History

During four years, from 1983 to 1987, numerous tools have been tried. Let's signal particularly the following companies:

- TRIEFUS
- FFDM – PNEUMAT
- GF – HANSOTTE
- KOMET
- DIAMECA

It was necessary, in the first place, to define the shape of the drill. To do that, several ranges were tried. During the 1985 ADF, we have defined the following tools:

- KOMETT	72	104 050
	H41	104 014
	H46	204 012
	H33R	104 016
	H138E	104 023
	74	104 050

It was necessary to fix a leaning ring on the type of tool (2.37 diameter) in order to have a perfect idea of the position of each tool with regards to the piece to manufacture (figure 92). During 1986, we have devised a manufacturing range for pre molars by changing such or such tool shape. Particularly, in order to get a good surface state, the shape of the tool of the intrados was blocked after numerous tests. The tool were valuable for the teeth.

5.2 Function of each tool (figures 93 to 103)

5.2-1 Cylindrical tools (PLN/0005/MF)

This tool is used for the rough pre shape (preparation and draft). That is why this tool must be robust and must have a very good life span of cutting power, in order to minimise the frequency of tool change, time and manufacturing efforts.

Use conditions:

- rotation speed: 42 000 t/m
- brooch movement speed: 15mm/s
- pass depth: 0.5mm to 1mm

For a crown, this drill runs on average 900mm manufacturing distance. So there is a necessity of rather long life span depending on the tool's wear percentage. This tool doesn't need great precision, just the average h10, h11.

5.2-2 Spherical tools (PLN/0006,7,8/MF)

The whole realisation of a crown and the manufacturing precision will depend on the quality and the precision of these three tools. Each tool has a semi finish phase and a finishing phase. The spherical tool must work as well on the superior part of the sphere. That is why, the shape between the superior cutting part and the tail of the tool must be conical, with a narrowing and on the superior quarter of the sphere to avoid collision between the manufactured piece and the tool's body (figure 95). The manufacturing of these tools must be careful and the precision of the realisation is on two points:

- the spherical shape of the cutting part of the tool
- the manufacturing precision must be around h7 (equivalent to reamers)

Spherical tools run, on a crown, the following distances:

PLN/0006/MF	diam. 3	1480mm
PLN/0007/MF	diam.1,2	400mm
PLN/0008/MF	diam. 0,6	185mm

Use conditions:

- rotation speed: 33 600 t/m
- brooch movement speed: 8mm/s
- pass depth: not controlled (1mm maximum), 3D tool movement

Given the distances ran, the precision and the manufacturing quality asked, it is necessary to do tools of high quality for an important life span.

5.2-3 Sharp tool

The function of this tool resides in its pointy shape. Currently, we keep the elliptic shape, knowing it may be modified (to pointy shape). The distance ran is around 110mm for a crown. The precision and the hardness of this tool must be enough to keep the general shape (h10).

Use conditions:

- rotation speed: 33 600 t/m
- brooch movement speed: 8mm/s
- pass depth: not controlled (0.5mm maximum), 3D tool movement

5.2-4 Toric tools (PLN/0010/MF)

The function of this tool is manufacturing and finish of the counter remains (figure 95). The link between the sharp part and the tail of the tool is the same as the spherical tools. The precision of manufacturing of the tool is the same as the spherical tools (h7).

The distance ran is around 400mm.
Use conditions:

- rotation speed: 42 000 t/m
- brooch movement speed: 15mm/s
- pass depth: very low, not controlled around 0.2mm

5.2-5 The drill

This tool must drill the necessary holes for the manufacturing of the intrados. The only constraint is the tool's life span.
Use conditions:

- rotation speed: 33 600 t/m
- brooch movement speed: 3mm/s

5.2-6 Cylindrical tool with spherical tip (PLN/0011/MF)

The manufacturing of the whole inferior part of the crown is done with this tool (manufacturing of the intrados). It must be precise and robust as it is used both as draft tool and a finishing tool. The precision of this tool must be the same as the other finishing tools (h7), equivalent to the reamers. The distance ran is around 700mm. Given the use rate of this tool and of its precision, it is necessary to have an important quality and life span.
Use conditions:

- rotation speed: 38 300 t/m
- brooch movement speed: 8mm/s
- pass depth: around 0,2mm

Note:

PRECISION TABLE

DIAMETRES	Précision en μ		
	h.7	h.10	h.11
1 à 3	0 - 10	0 - 40	0 - 60
3 à 6	0 - 12	0 - 48	0 - 75

5.3 Composition of tools

5.3-1 Shape

It is defined in "LAMBERT's" drawing (figure 92)

5.3-2 Materials

a) TOOLS MATERIALS

We have studied at least three propositions showing the advantages, inconvenients and conditions in each case, which are:

- tools in mono bloc steel (tungsten carbora)
- tools in rapid steel with titan or nitrure de bore or other coating
- tools in rapid steel with the sharp part in diamond

Note: any other solution to optimise the manufacturing conditions can be envisaged.

b) NUMBER OF TEETH

The mechanical characteristics of the material have not yet been chosen. The number of teeth will be determined by the manufacturer with your collaboration to optimise the conditions and manufacturing time (cutting angle, pass depth, surface state…). They are currently being studied in Bordeaux.

5.3-3 Ring

The mounting height of the tool inside the brooch is determined by a ring fixed on the tool, see "LAMBERT" drawing. The characteristics of the ring:

- superficially hardened material
- the spherical surface is polished
- the quality of the diameter surface depends on the fixation mode of the tool (ex; glueing)

5.4 Manufacturing

The tools are manufactured by the DIAMECA company fro Geneva (the prototypes are being studied)

5.5 Conclusion

After trials by LOUIS, we are able to define the definitive material and the number of teeth for each tool. In the mean time, we know the shape of each tool as well as their dimensions. The practioner will only have to place each tool in its place depending on its number from 1 to 8 (which are known, see drawing). All there is left to do is define the polishing mode currently being studied.

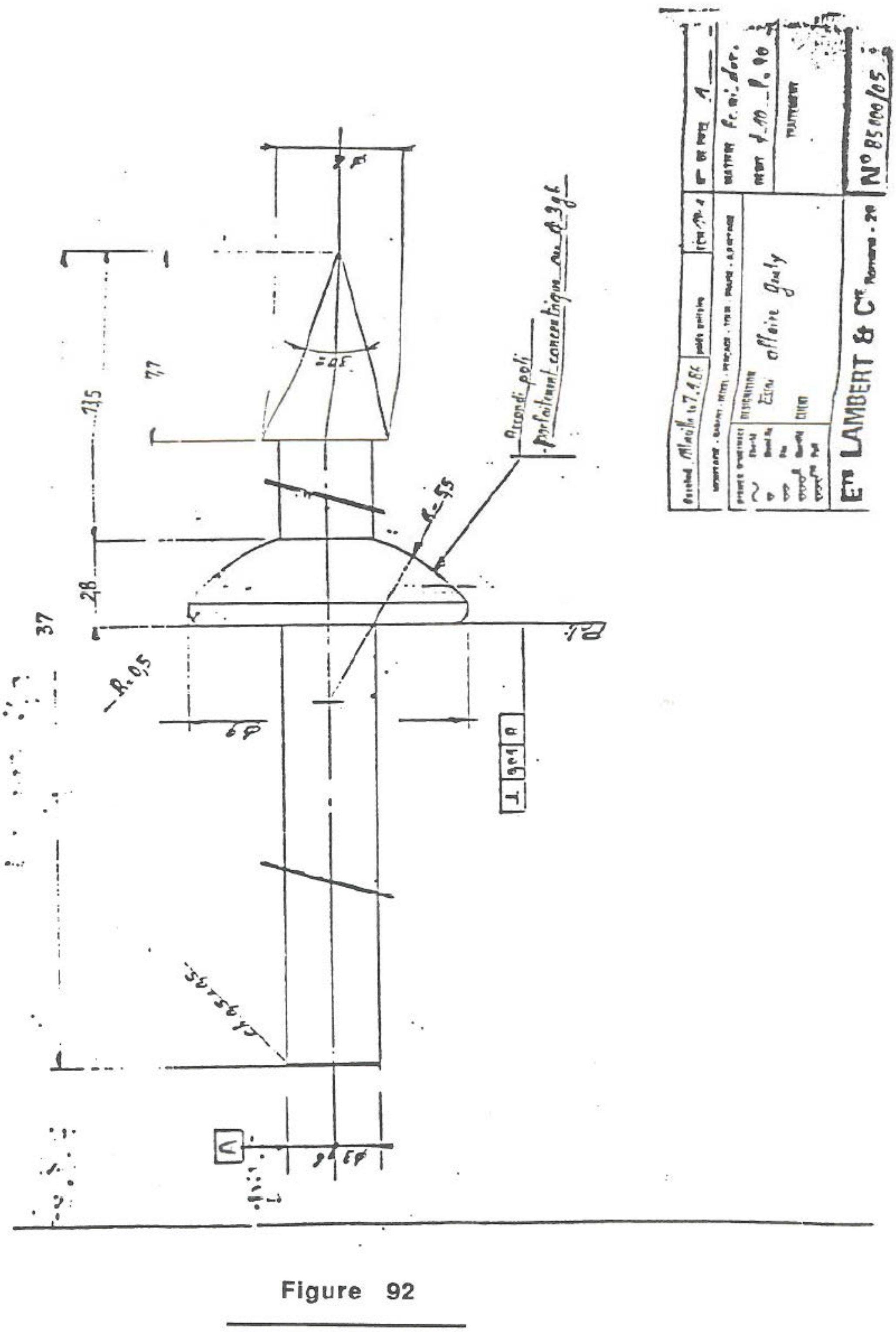


Figure 92

Outils et conditions souhaités.

Tableau 2

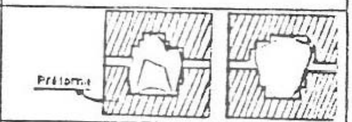
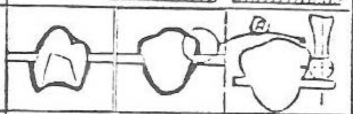
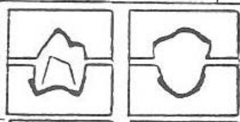
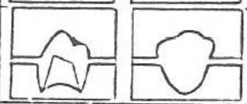
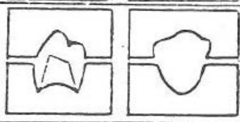
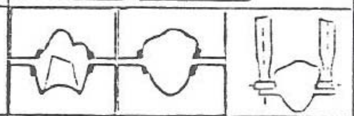
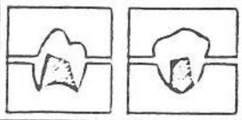
	N° PLAN	Diam. partie coupante en mm	Nbre de lèvres	Angle d'hélice	Précision en micron	Vitesse rotation t/mn	Vitesse Avance mm/s	Profondeur de passe en mm	Dist. d'usinage moyenne en mm	Fonction	Descriptif
[illegible]	PLN/0005/FF	4	4	30°	h11	40.000	15	0,5 à 1	900	Ebauche	
[illegible]	PLN/0006/FF	3	6	15°	h7	60.000	40	1 maxi	1420	1/2 finition et finition	
[illegible]	PLN/0007/FF	1,2	6	15°	h7	40.000	40	0,5 maxi	400	1/2 finition et finition	
[illegible]	PLN/0008/FF	0,6	6	15°	h7	40.000	40	0,3 maxi	185	1/2 finition et finition	
	PLN/0009/FF	elliptique	6	-	h10 ou 11	40.000	40	0,5 maxi	110	finition	
	PLN/0010/FF	4 rayon 0,5	diamant ou B	-	h7	40.000	40	0,3 maxi	400	finition	
[illegible]	PLN/0011/FF	1,5	4	30	h7	40.000	40	0,2	700	finition	

Figure 93

Outils utilisés actuellement — Conditions actuelles

Tableau 1

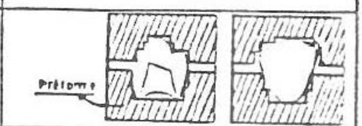
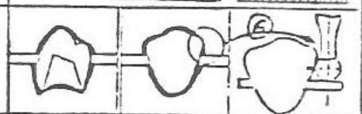
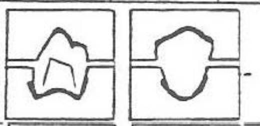
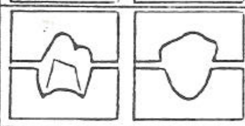
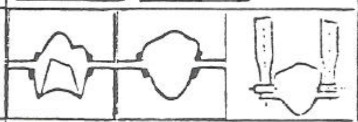
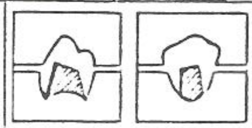
N° PLAN	Diam. partie coupante en mm	Nbre de lèvres	Angle d'hélice	Précision en micron	Vitesse rotation t/mn	Vitesse Avance mm/s	Profondeur de passe en mm	Dist d'usinage moyenne en mm	Fonction	Descriptif
PLN/0005/MF	4	4	30°	h11	47 000	15	0,5 à 1	900	Ebauche	
PLN/0006/MF	3	8	15°		33 600	8	1 maxi	1450	1/2 finition et finition	
PLN/0007/MF	1,2	6	15°		33600	8	0,5 maxi	400	1/2 finition et finition	
PLN/0008/MF	0,6	6	15°		33600	8	0,3 maxi	185	1/2 finition et finition	
PLN/0009/MF	elliptique	lime	droit		33600	8	0,5 maxi	110	finition	
PLN/0010/MF	4 rayon 0,6	6 lames	-		42000	15	0,3 maxi	400	finition	
PLN/0011/MF		lime	30		33600	8	0,2	700	finition	

Figure 94

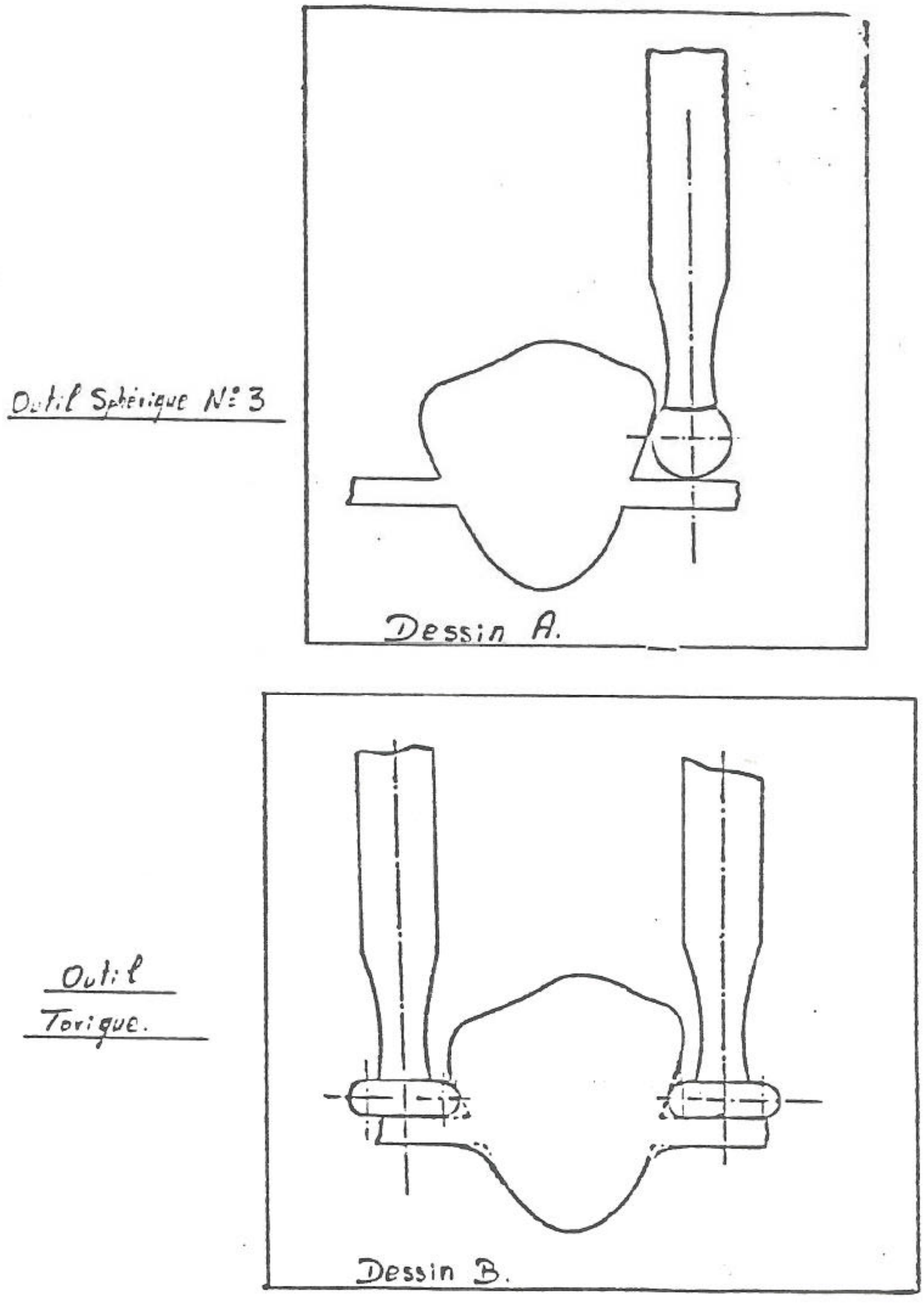
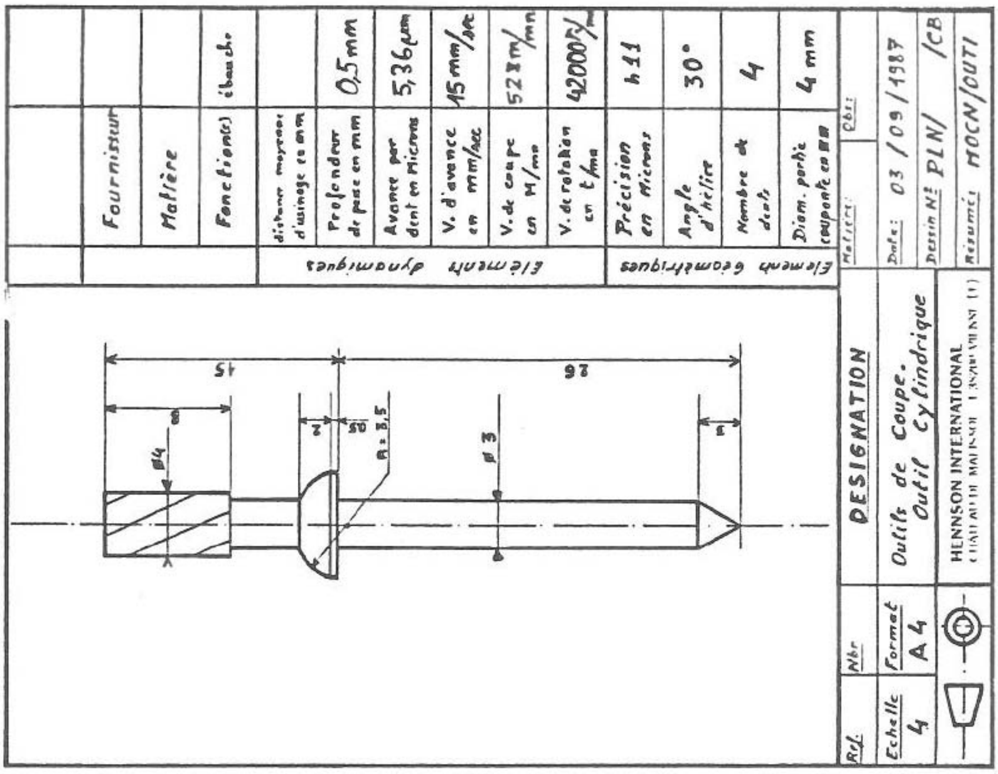


Figure 95


DESIGNATION
Outils de Coupe.
Outil Cylindrique
HENNSON INTERNATIONAL
Fournisseur
Matière
Fonction(s) ébauche
Profondeur de passe en mm 0,5mm
Avance par dent en Microns 5,36µm
V. d'avance en mm/sec 15 mm/sec
V. de coupe en M/mn 528 m/mn
V. de rotation en t/mn 42000 t/mn
Précision en Microns h11
Angle d'hélice 30°
Nombre de dents 4
Diam. partie coupante en mm 4 mm
Echelle 4
Format A4
Date: 03/09/1987
Dessin N° PLN/ /CB
Résumé MOCN/OUTI

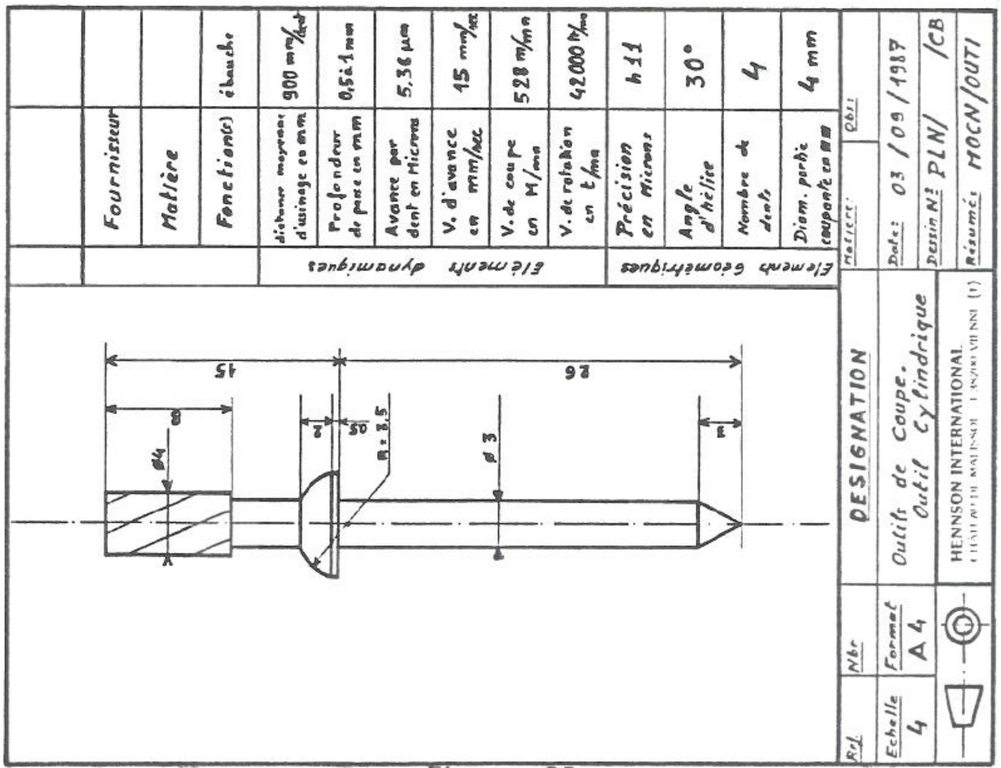
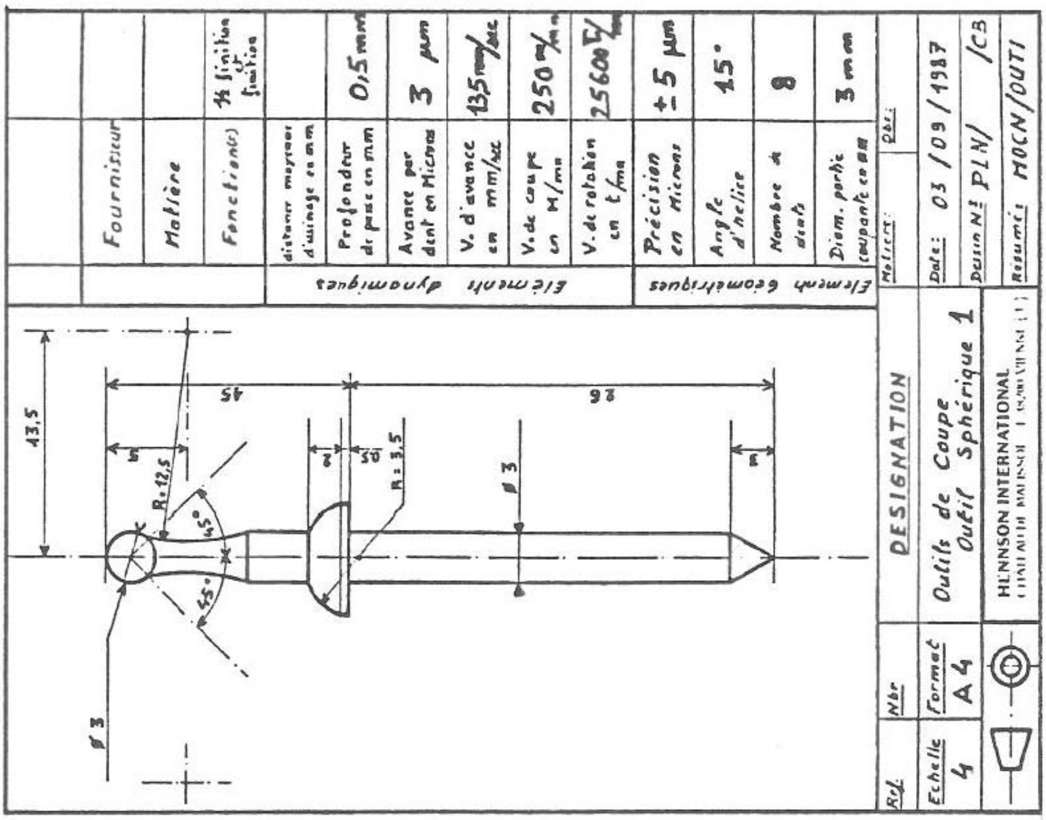

DESIGNATION
Outils de Coupe.
Outil Cylindrique
HENNSON INTERNATIONAL
Fournisseur
Matière
Fonction(s) ébauche
distance moyenne d'usinage en mm 900 mm/sec
Profondeur de passe en mm 0,5 à 1 mm
Avance par dent en Microns 5,36 µm
V. d'avance en mm/sec 15 mm/sec
V. de coupe en M/mn 528 m/mn
V. de rotation en t/mn 42000 t/mn
Précision en Microns h11
Angle d'hélice 30°
Nombre de dents 4
Diam. partie coupante en mm 4 mm
Echelle 4
Format A4
Date: 03/09/1987
Dessin N° PLN/ /CB
Résumé MOCN/OUTI

Figure 96



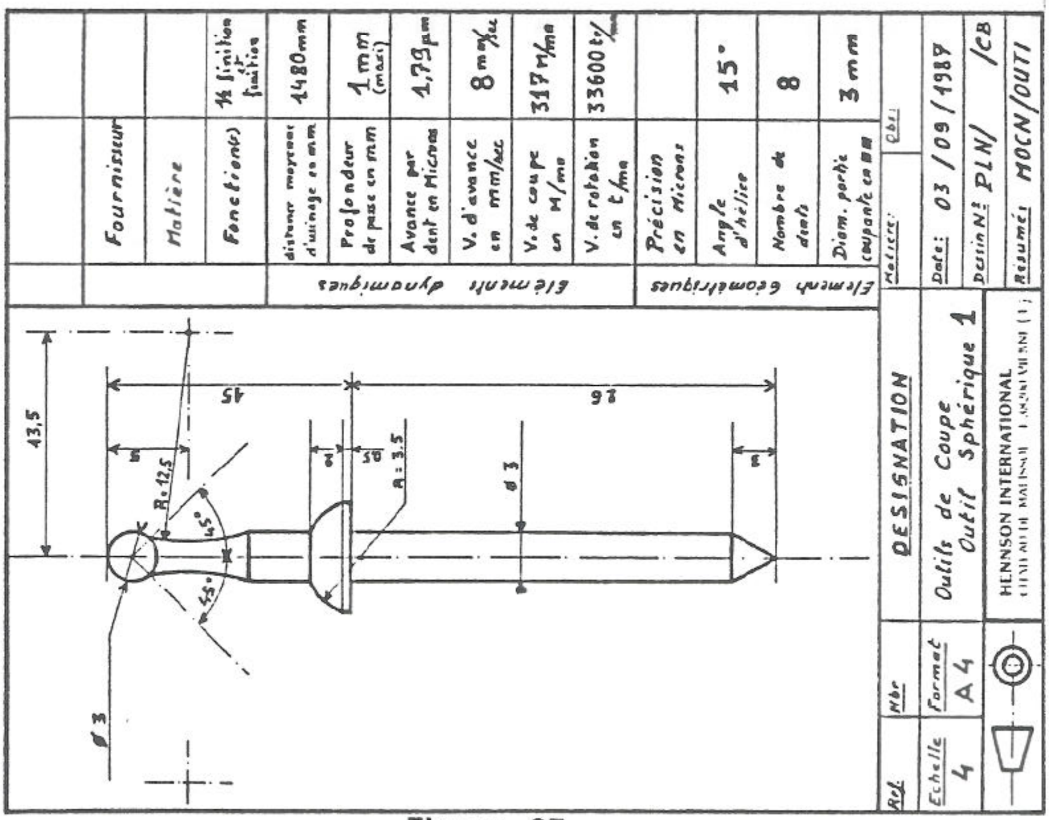
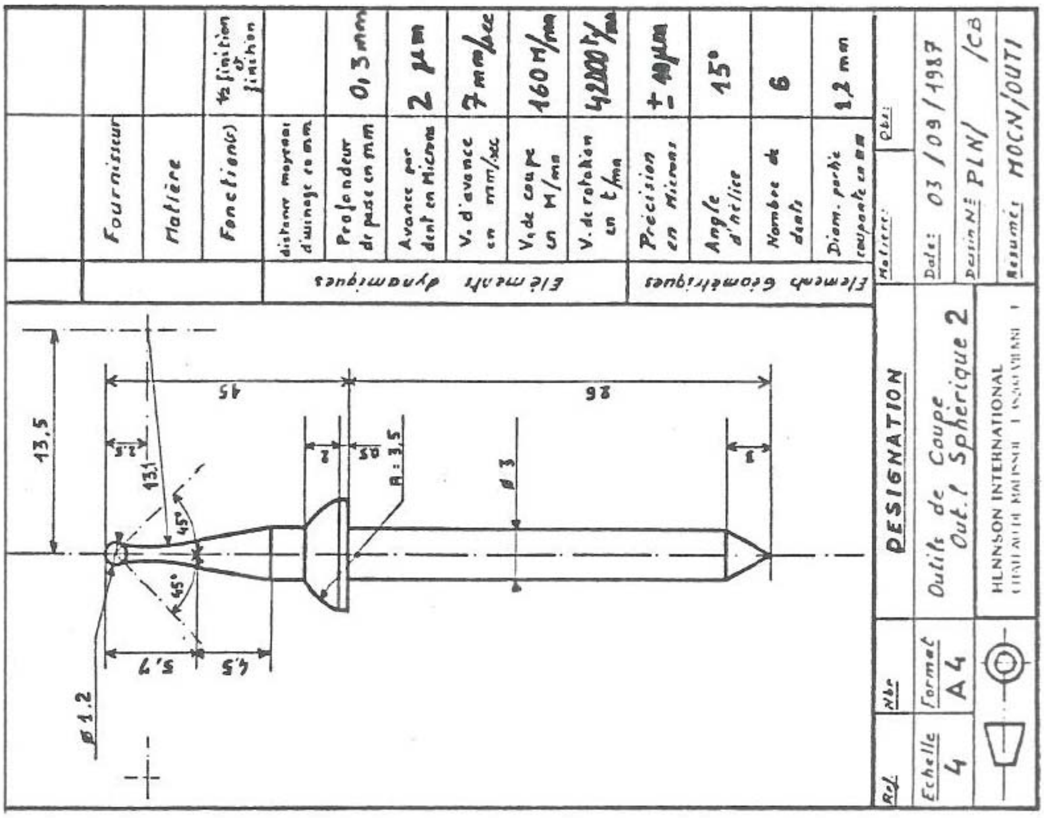


Figure 97


Fournisseur
Matière
Fonction(s)
½ finition et finition
distance moyenne d'usinage en mm
Profondeur de passe en mm
0,3 mm
Avance par dent en Microns
2 µm
V. d'avance en mm/sec
7 mm/sec
V. de coupe en M/mn
160 M/mn
V. de rotation en t/mn
42000 t/mn
Précision en Microns
Angle d'hélice
15°
Nombre de dents
6
Diam. partie coupante en mm
1,2 mm
Eléments dynamiques
Eléments Géométriques
13,5
13,1
45°
45
86
R : 3,5
ø 3
ø 1.2
DESIGNATION
Outils de Coupe
Out.l Sphérique 2
HENNSON INTERNATIONAL
Ref
Nbr
Echelle
4
Format
A4
Matière
Obs
Date: 03 / 09 / 1987
Dessin N° PLN/ /CB
Résumé MOCN/OUTI

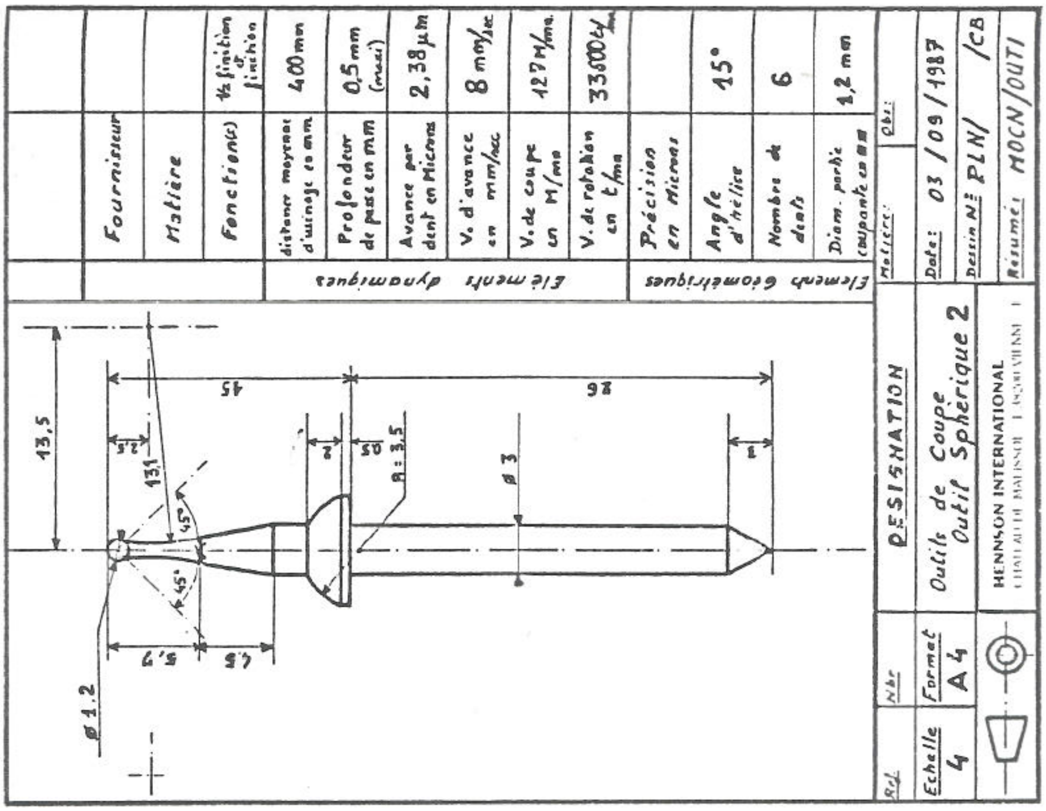
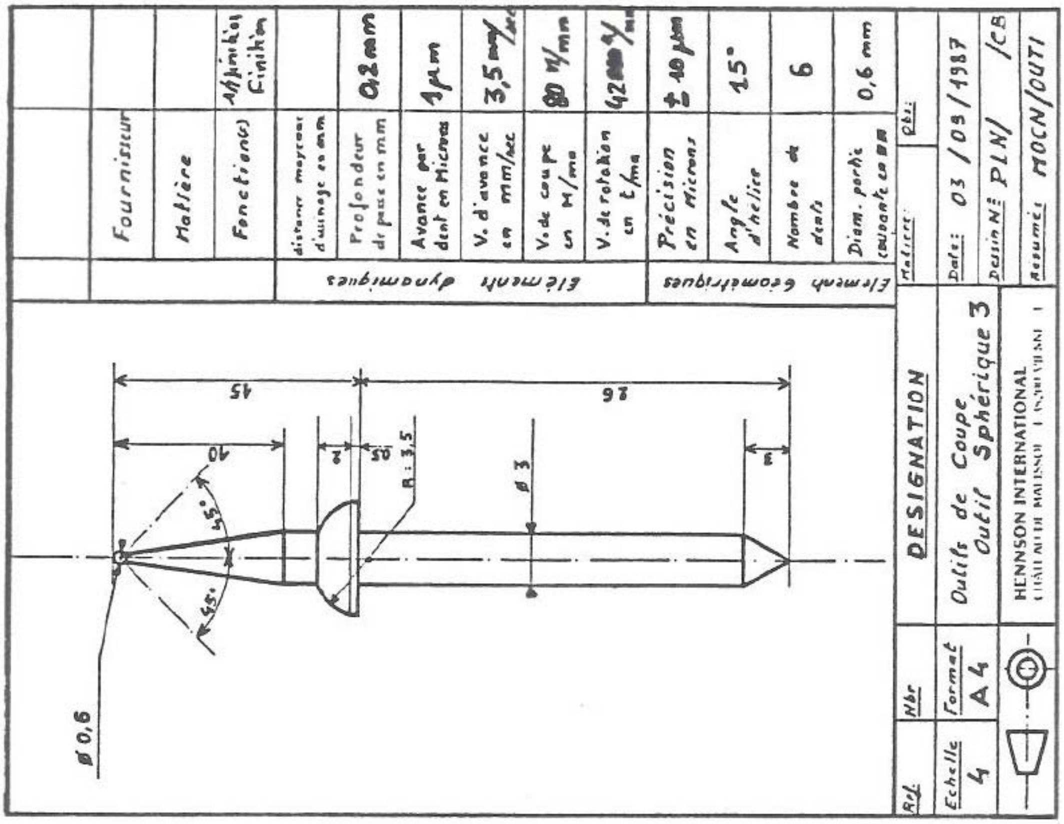

Fournisseur
Matière
Fonction(s)
½ finition et finition
distance moyenne d'usinage en mm
4,00 mm
Profondeur de passe en mm
0,5 mm (maxi)
Avance par dent en Microns
2,38 µm
V. d'avance en mm/sec
8 mm/sec
V. de coupe en M/mn
127 M/mn
V. de rotation en t/mn
33800 t/mn
Précision en Microns
Angle d'hélice
15°
Nombre de dents
6
Diam. partie coupante en mm
1,2 mm
Eléments dynamiques
Eléments Géométriques
13,5
13,1
45°
45
86
R : 3,5
ø 3
ø 1.2
DESIGNATION
Outils de Coupe
Outil Sphérique 2
HENNSON INTERNATIONAL
Ref
Nbr
Echelle
4
Format
A4
Matière
Obs
Date: 03 / 09 / 1987
Dessin N° PLN/ /CB
Résumé MOCN/OUTI

Figure 98


Fournisseur
Matière
Fonction(s)
distance moyenne d'usinage en mm
Profondeur de passe en mm
0,2 mm
Avance par dent en Microns
1 µm
V. d'avance en mm/sec
V. de coupe en M/mn
V. de rotation en t/mn
Précision en Microns
± 10 µm
Angle d'hélice
15°
Nombre de dents
6
Diam. partie coupante en mm
0,6 mm
Eléments dynamiques
Eléments Géométriques
Obs:
Date: 03 / 09 / 1987
Dessin Nº PLN/ /CB
Résumé: MOCN/OUTI
DESIGNATION
Outils de Coupe
Outil Sphérique 3
HENNSON INTERNATIONAL
Echelle 4
Format A4
Ref
Nbr
ø 0,6
45°
45°
10
15
R: 3,5
ø 3
26

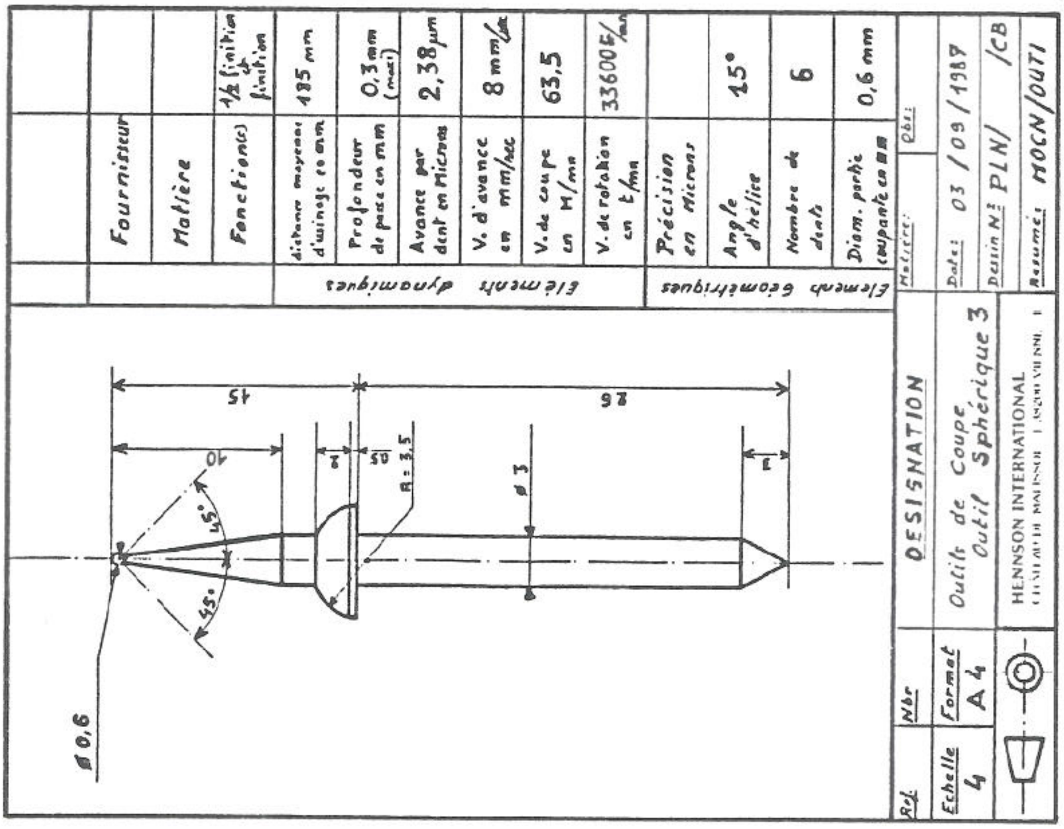
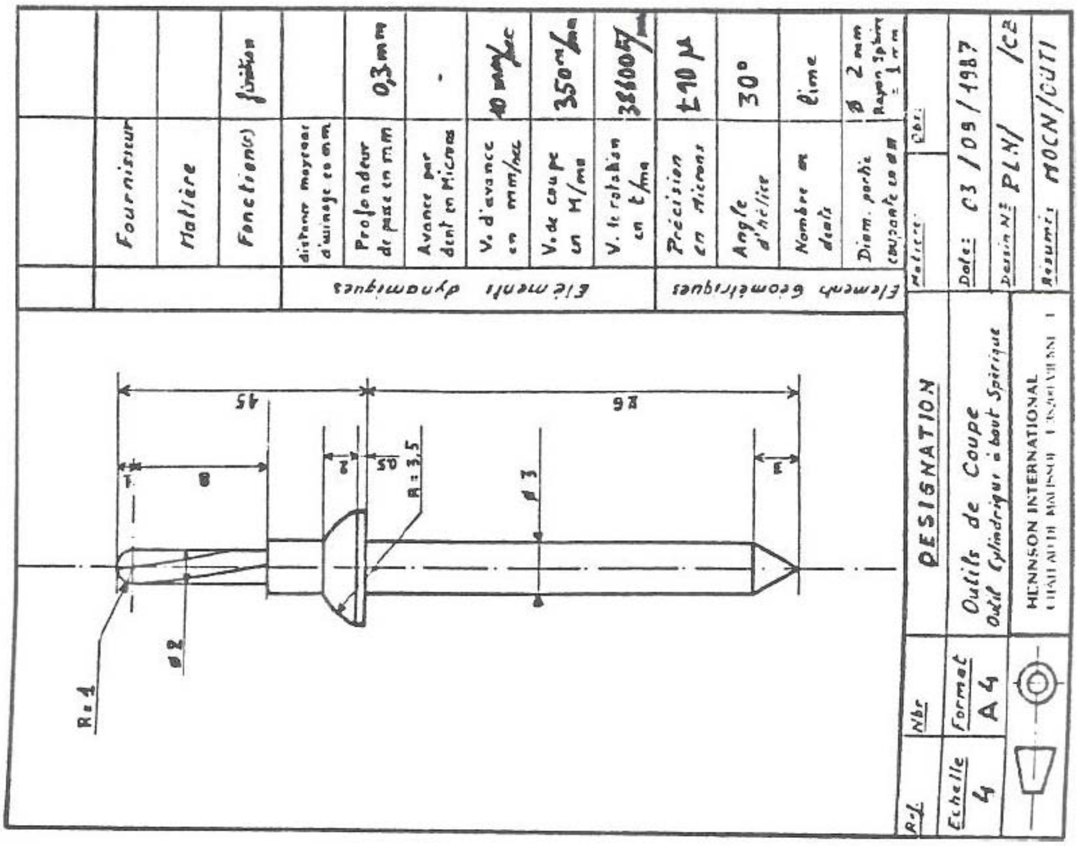

Fournisseur
Matière
Fonction(s)
1/2 finition de finition
distance moyenne d'usinage en mm
1,25 mm
Profondeur de passe en mm
0,3 mm (maxi)
Avance par dent en Microns
2,38 µm
V. d'avance en mm/sec
8 mm/sec
V. de coupe en M/mn
63,5
V. de rotation en t/mn
33600 t/mn
Précision en Microns
Angle d'hélice
15°
Nombre de dents
6
Diam. partie coupante en mm
0,6 mm
Eléments dynamiques
Eléments Géométriques
Obs:
Date: 03 / 09 / 1987
Dessin Nº PLN/ /CB
Résumé: MOCN/OUTI
DESIGNATION
Outils de Coupe
Outil Sphérique 3
HENNSON INTERNATIONAL
Echelle 4
Format A4
Ref
Nbr
ø 0,6
45°
45°
10
15
R: 3,5
ø 3
26

Figure 99


Fournisseur
Matière
Fonction(s) finition
distance moyenne d'usinage en mm
Profondeur de passe en mm 0,3 mm
Avance par dent en Microns -
V. d'avance en mm/sec 10 mm/sec
V. de coupe en M/mn 350 m/mn
V. de rotation en t/mn 38600 t/mn
Précision en Microns ±10 µ
Angle d'hélice 30°
Nombre de dents lime
Diam. partie coupante en mm Ø 2 mm Rayon Sphère = 1 mm
Eléments dynamiques
Eléments Géométriques
DESIGNATION
Outils de Coupe
Outil Cylindrique à bout Sphérique
HENNSON INTERNATIONAL
Echelle 4
Format A4
Date: 03/09/1987
Dessin N° PLN/ /C2
Résumé: MOCN/OUTI

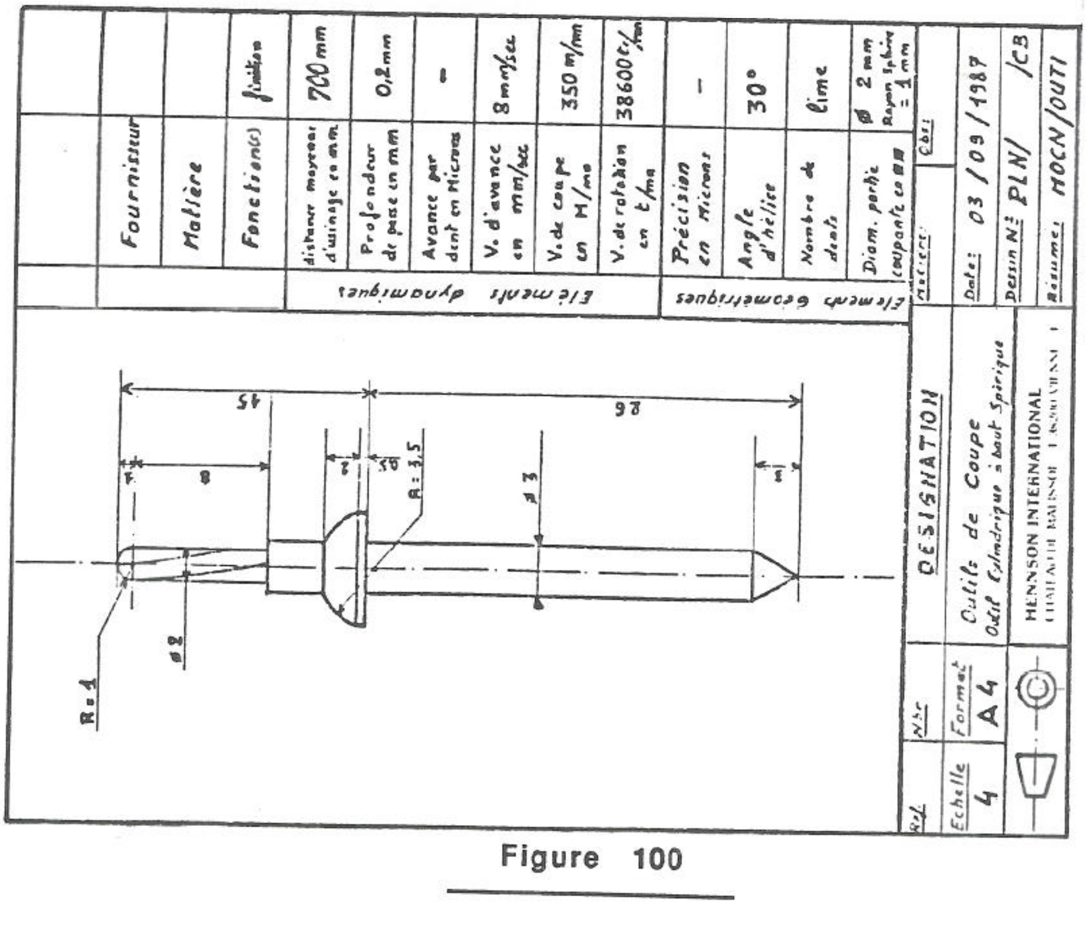
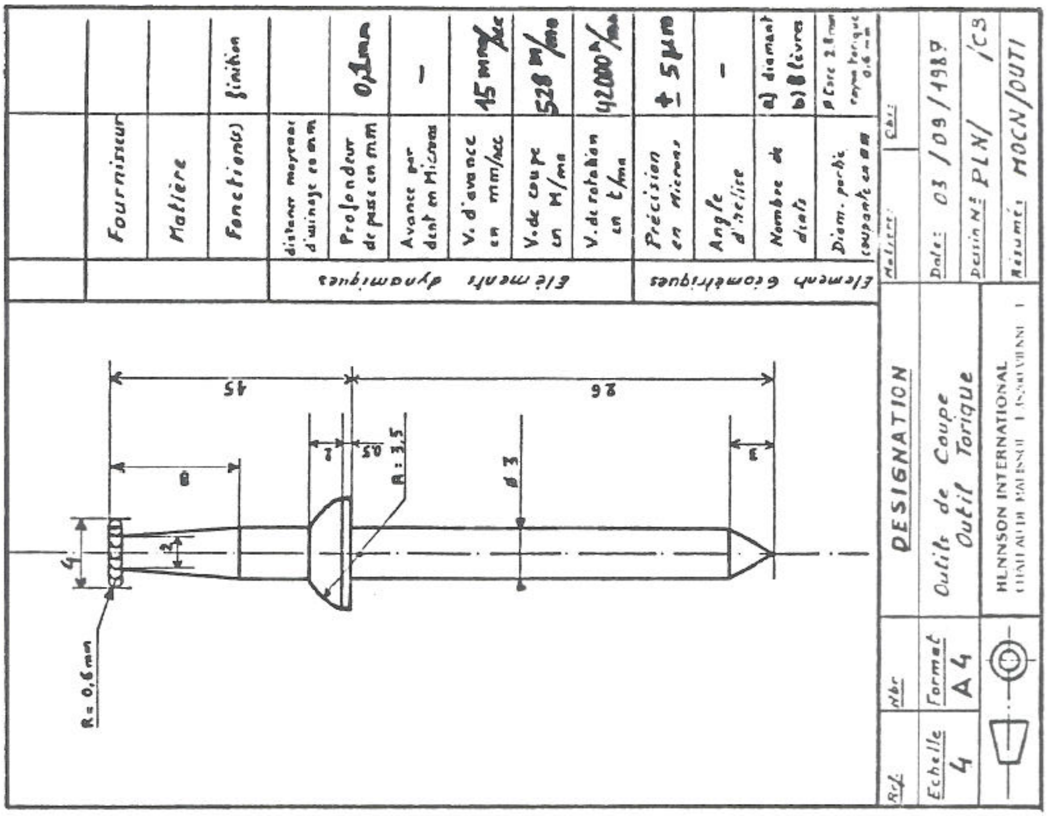

Fournisseur
Matière
Fonction(s) finition
distance moyenne d'usinage en mm 700 mm
Profondeur de passe en mm 0,2 mm
Avance par dent en Microns -
V. d'avance en mm/sec 8 mm/sec
V. de coupe en M/mn 350 m/mn
V. de rotation en t/mn 38600 t/mn
Précision en Microns -
Angle d'hélice 30°
Nombre de dents lime
Diam. partie coupante en mm Ø 2 mm Rayon Sphère = 1 mm
Eléments dynamiques
Eléments Géométriques
DESIGNATION
Outils de Coupe
Outil Cylindrique à bout Sphérique
HENNSON INTERNATIONAL
Echelle 4
Format A4
Date: 03/09/1987
Dessin N° PLN/ /C3
Résumé: MOCN/OUTI

Figure 100



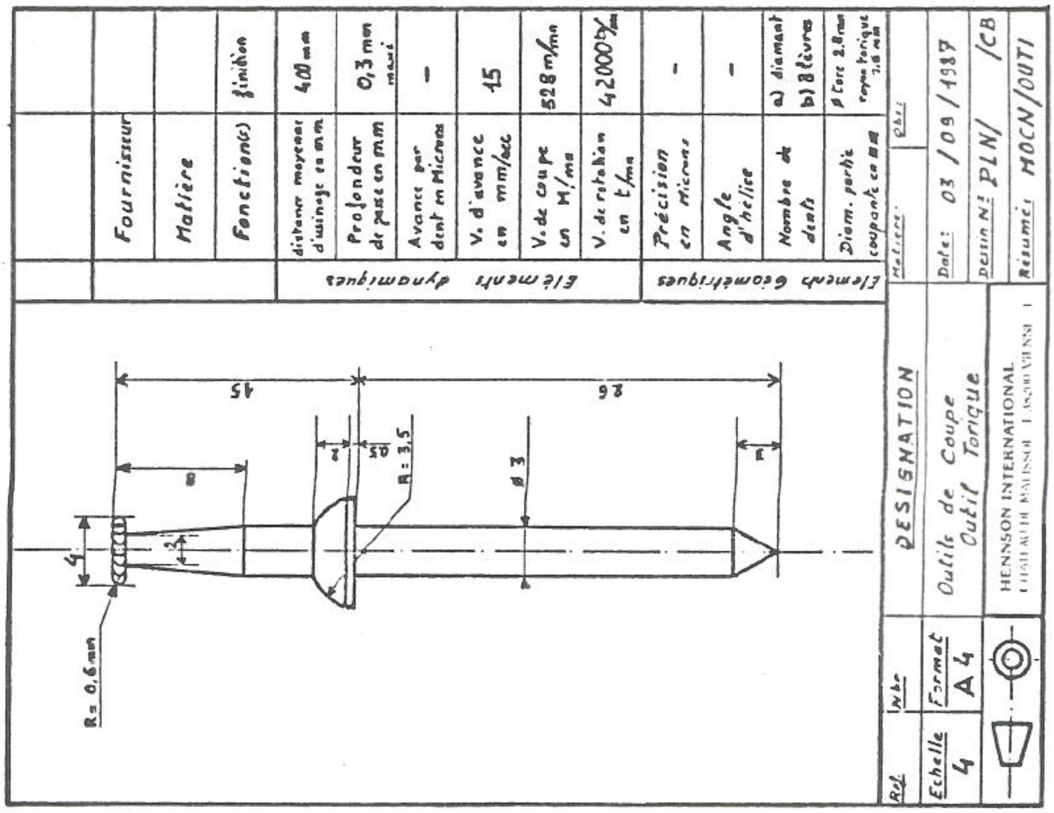
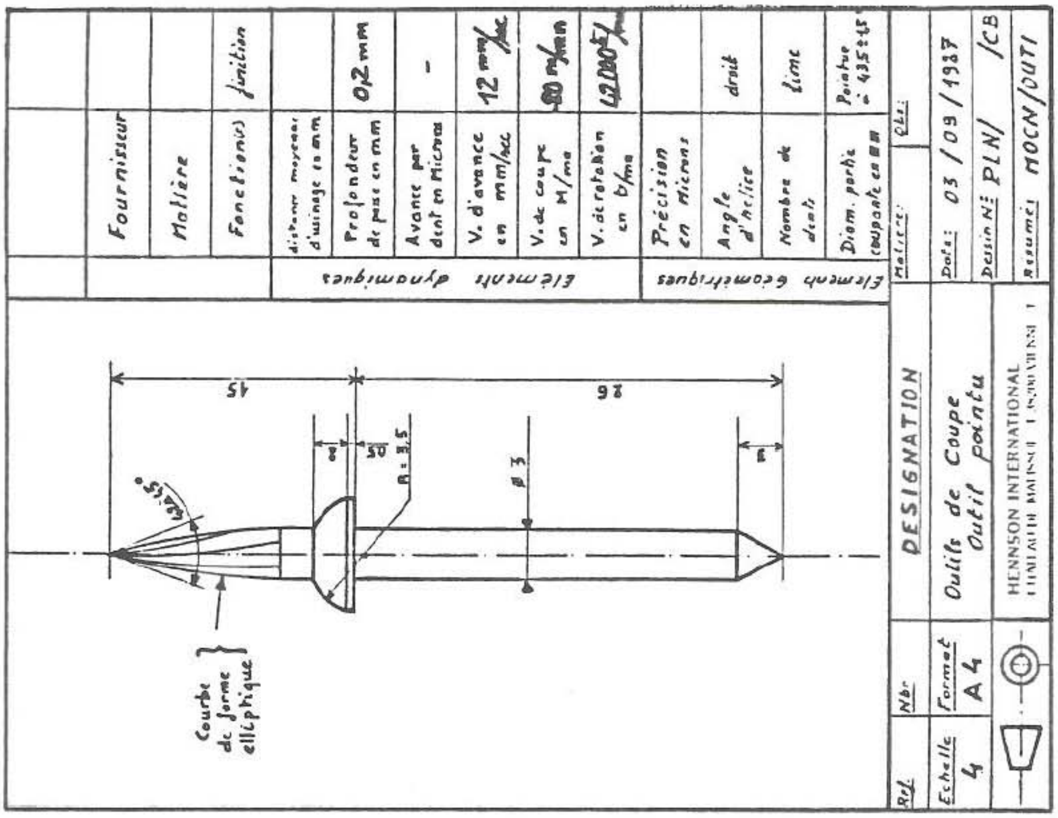


Figure 101


Fournisseur
Matière
Fonction(s)
finition
Profondeur de passe en mm
0,2 mm
Avance par dent en Microns
V. d'avance en mm/sec
V. de coupe en M/mn
V. de rotation en t/mn
Précision en Microns
Angle d'hélice
droit
Nombre de dents
lime
Diam. partie coupante en mm
Éléments dynamiques
Éléments Géométriques
Courbe de forme elliptique
DESIGNATION
Outils de Coupe
Outil pointu
Date: 03 / 09 / 1987
Dessin N°: PLN/ /CB
Résumé: MOCN/OUTI
Echelle 4
Format A4
HENNSON INTERNATIONAL

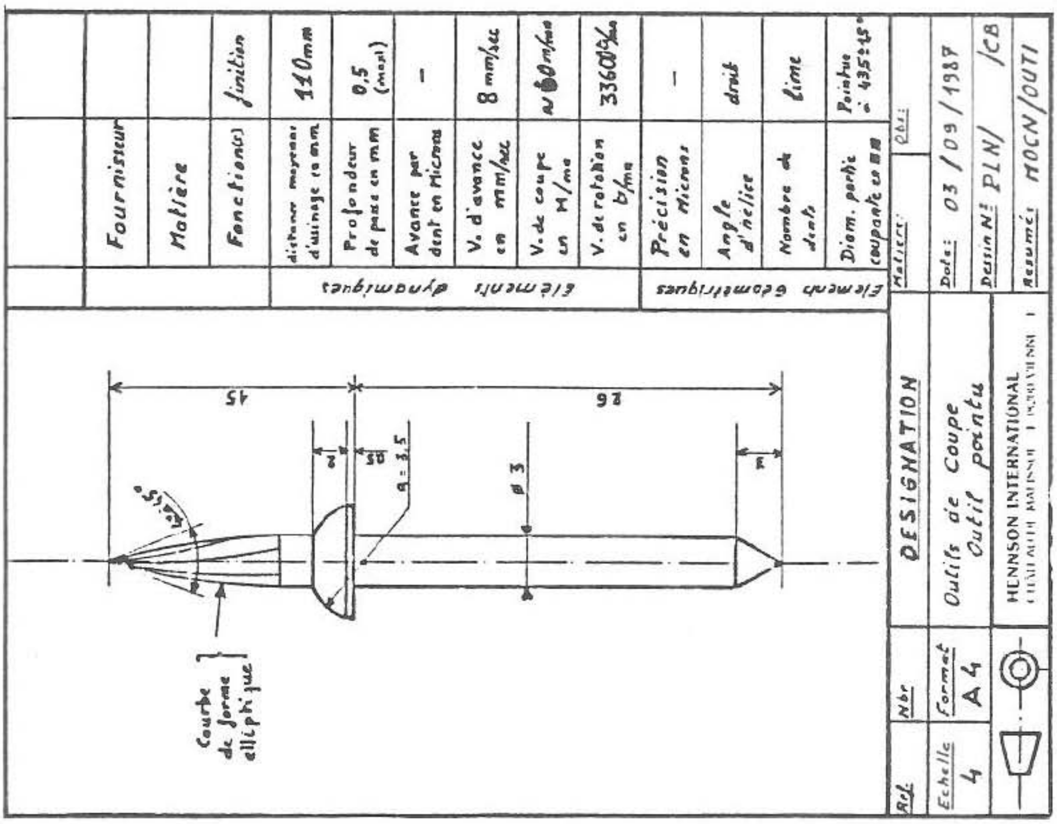

Fournisseur
Matière
Fonction(s)
finition
110 mm
Profondeur de passe en mm
0,5 (maxi)
Avance par dent en Microns
V. d'avance en mm/sec
8 mm/sec
V. de coupe en M/mn
V. de rotation en t/mn
33600 t/mn
Précision en Microns
Angle d'hélice
droit
Nombre de dents
lime
Diam. partie coupante en mm
Éléments dynamiques
Éléments Géométriques
Courbe de forme elliptique
DESIGNATION
Outils de Coupe
Outil pointu
Date: 03 / 09 / 1987
Dessin N°: PLN/ /CB
Résumé: MOCN/OUTI
Echelle 4
Format A4
HENNSON INTERNATIONAL

Figure 102

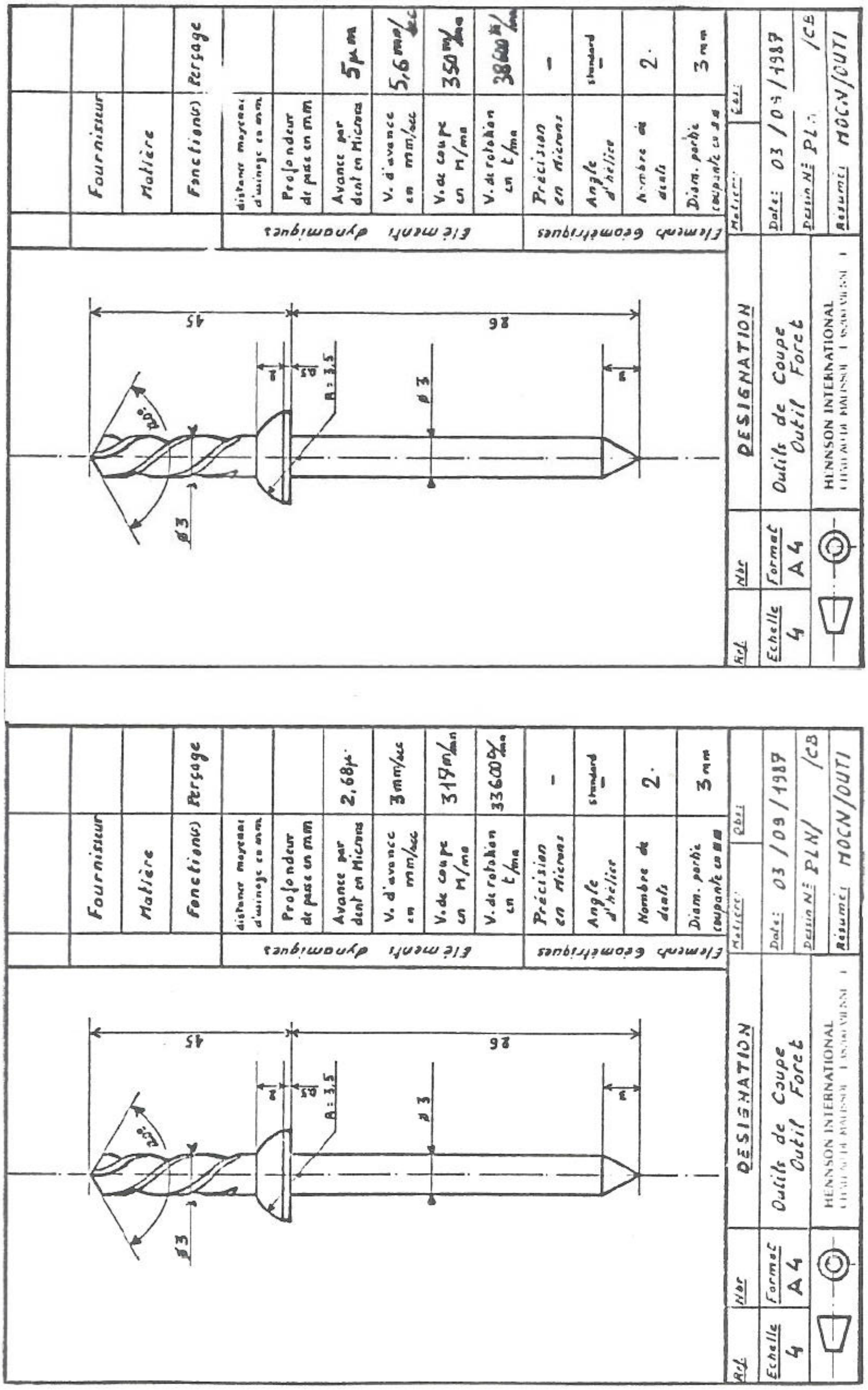

Fournisseur
Matière
Fonction(s)
Perçage
DESIGNATION
Outils de Coupe
Outil Foret
HENNSON INTERNATIONAL
Echelle
4
Format
A4
Date: 03/09/1987
Résumé: MOCN/OUTI

Figure 103

6-MATERIALS

Computer aided conception of dental prosthesis defines with great precision and a constant reproducibility the ideal prosthetic volume wanted by clinical imperatives. Then this prosthetic volume will be converted in a definitive prosthesis by digital command manufacturing in a bio material bloc devised for a precise clinical objective.

Presented un this super simplified aspect, this new technology plunges in a deep reflexion the creators of bio materials who see their specifications fundamentally disturbed since it is not the reproduction of shapes imperatives which are important anymore but the specialities of substance loss. It appears that current bio materials have no interest as they are malleable and their biological properties are often second to this imperative which is nevertheless essential for current dental prostheses. Thus, we see the arrival inside the mouth of unsuspected substances such as:

- metals (gold, steel, alloys) for their aptitude to reproduce shapes by using lost wax methods and their mechanical properties
- aesthetical substances, charged or non resins and ceramics, pretty but without the sufficient mechanical properties

Both ensembles are often associated to form a coherent set.

6.1 Research aim

CAD/CAM gives us the prosthetic shape and volume. We must now devote our research entirely to one or more materials whose mechanical, biological and aesthetic specificities, associated to the fixation on the receiving site process will enable us to satisfy better the clinical requirements.

The biggest priority will be given to the statistical and dynamic study of the tissue to be replaced, then to the implementation of a substance capable of replacing it. It appears to be logical to start by clearly defining our needs according to the tissue we want replaced, and its function. This is in our view, a new way of doing things as it's not the implementation technique of a material or its original particularities who are going to define our clinical concepts but rather the opposite.

6.2 Research methods – specifications

In fact, all we need to do is devise without any other practical considerations the material whose characteristics are closest to those of the tissue to be replaced. Then, we must condition this material so that it can be fixed then manufactured on the digital command device. This implies the writing of specifications of the bio material. This type of study will always start by a precise analysis of the needs, that is to say the close examination of the substance loss. Only after will the reflexion, research and choice of bio material phases arrive.

For a better comprehension of things, we distinguish two aspects in the specifications:

- statistical characteristics
- dynamic characteristics

We study for each characteristic those specific to the loss of substance and we will deduce those desirable for the material.

6.2-1 Static characteristics

6.2-1.1 Substance loss

We keep for practical reasons this average values list given by authors to the dental structure as a reflexion base.

a) Physical properties

	EMAIL	DENTINE	
DENSITE :	2,2 à 3	2.	
INDICE DE REFRACTION :	1,655	1,55	
TRANSPARENCE	80 %	10 %	
P^és^ OPTIQUES	ANISOTROPE	ISOTROPE	
SOLUBILITE	INSOLUBLE DS LA SALIVE		
CHALEUR MASSIQUE	1600	1000	J/(Kg.°C)
CONDUCTIVITE THERMIQUE	0,9	0,5	W/(m.°C)
DIFFUSIVITE THERMIQUE	0,4	0,1	mm2/sec
DILATATION LINEIQUE	11	8	°(C^{-1}X10^6)

b) Mechanical properties

	EMAIL		DENTINE	
DURETE	340	KHN	70	KHN
COEFFICIENT DE FROTTEMENT	0,2		0,5	
MODULE D'ELASTICITE	80	GPa	18	GPa
COMPRESSION	350	MPa	280	MPa
TRACTION	45	MPa	15	MPa
FLEXION	90	MPa	140	MPa

6.2-1.2 Material

It will have to take into account the values of the substance loss without forgetting any. Here again, let's us remind that is the dental tissue that needs it!... Among these dental structure values, some, such as the scissoring values, flexion and traction, will be increased for safety reasons. Moreover, for some properties we will take into account the enamel values more than the dentine ones or vice versa depending on the clinical objectives. For example, in elasticity mode, we will take the radicular dentine value as it is for a radicular post and the enamel and coronary dentine values for a crown. Finally, we have approached our values, still for safety reasons, to those of the material leader for mechanical properties for prostheses: yellow gold. Thus rethought we have edited the specifications for the statistical specifications of the bio material for crowns, onlays and inlays for example:

a) Physical properties

DENSITE :	2,2 à 3	
INDICE DE REFRACTION :	1,5	
TRANSPARENCE	80	%
ANISOTROPE		
SOLUBILITE	INSOLUBLE DS LA SALIVE	
CHALEUR MASSIQUE	1000	J/(Kg.°C)
CONDUCTIVITE THERMIQUE	0,5	W/(m.°C)
DIFFUSIVITE THERMIQUE	0,1	mm2/sec
DILATATION LINEIQUE	8	$(°C^{-1} X 10^{6})$

b) Mechanical properties

DURETE	340	KHN ou 90 SHORE D
COEFFICIENT DE FROTTEMENT 0,2	0,5	
MODULE D'ELASTICITE	18	GPa
COMPRESSION	300	MPa
TRACTION	300	MPa
FLEXION	300	MPa

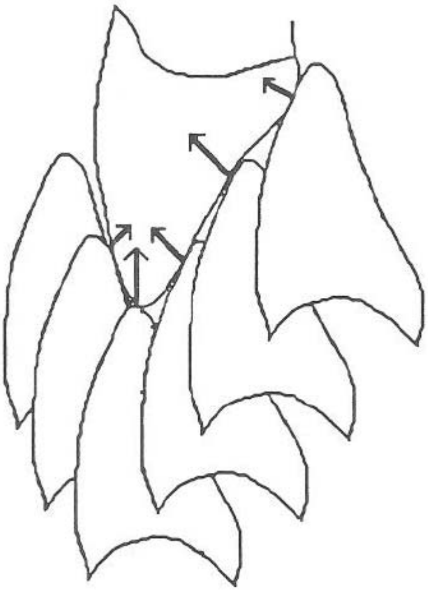
Evidently, such a material doesn't exist among the known bio materials used for dental prostheses (figure 106, 107, 108).

6.2-2 Dynamic characteristics

6.2-2.1 Substance loss

After having fixed those values, we are going to study all the dynamic constraints which will apply to the material during the different functional sequences of the mastication. In the case of a tooth it means we must envisage all possible cases on contact between teeth during the mandibular movements in all types of occlusion. In order to simplify this presentation, we will study these constraints for each tooth in the vertical way, vestibular lingual and palatal, mesio-distal and vice versa, then we will evaluate the behaviour in intermediary situations (figures 104, 105).

Dans le sens vestibulo-lingual nous distinguerons : Articulé inverse
Bout à bout
Intercuspidation maxima
Position balancée



Dans le sens mesio-distal : Bout à bout en rétrusion
Intercuspidation maxima
Bout à bout en protrusion

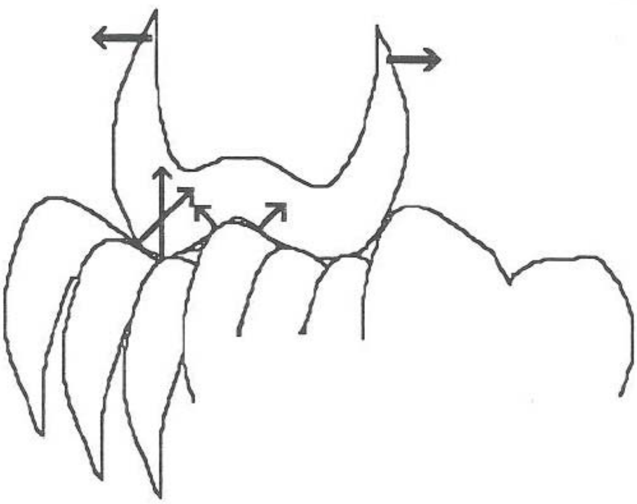
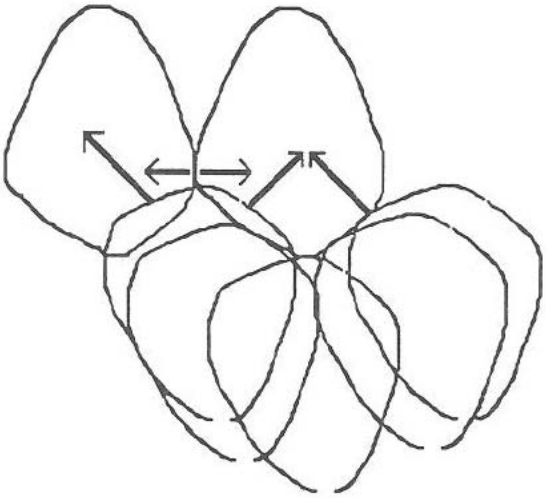
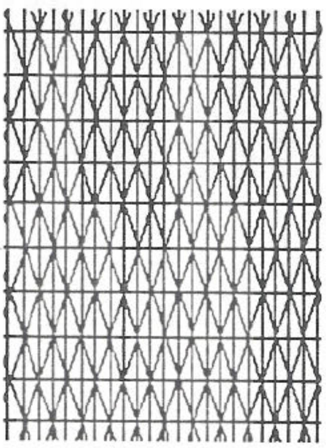
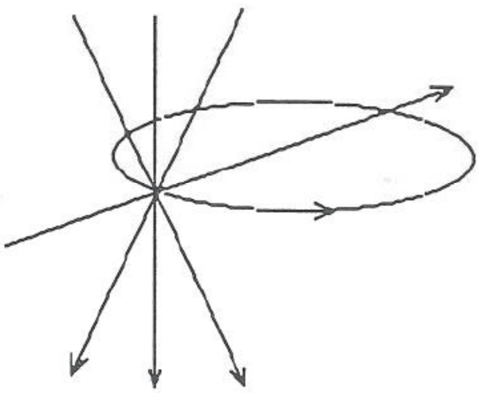


Figure 104





COUPE LONGITUDINALE
DE L'ARCHITECTURE
SELON UN DIAMETRE



REPRESENTATION SPATIALE AU NOEUD
D'INTERSECTION DES DIFFERENTES
ORIENTATIONS DU FILAMENT

Figure 105

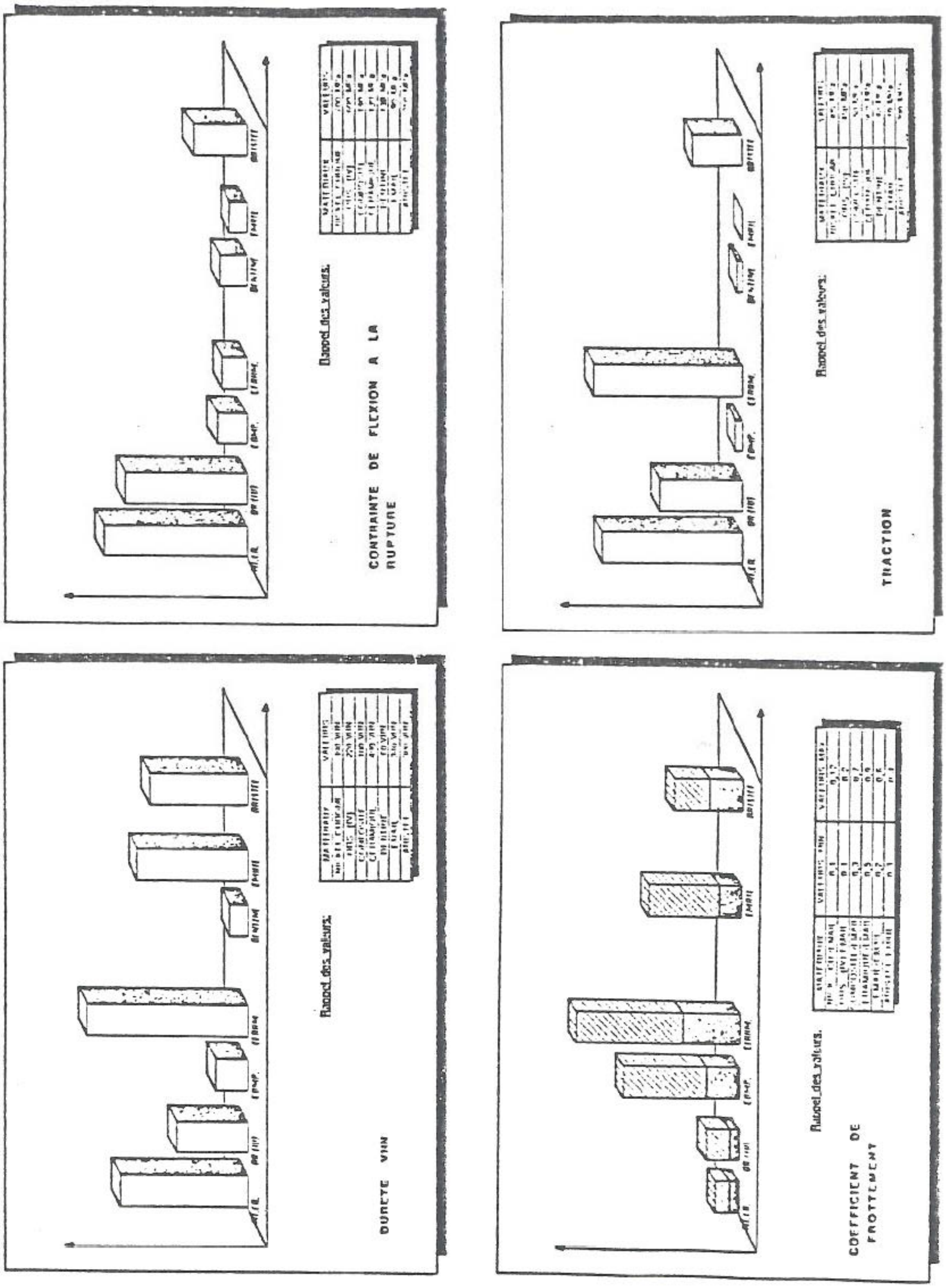


Figure 106

PROPRIETES PHYSIQUES DU MATERIAU

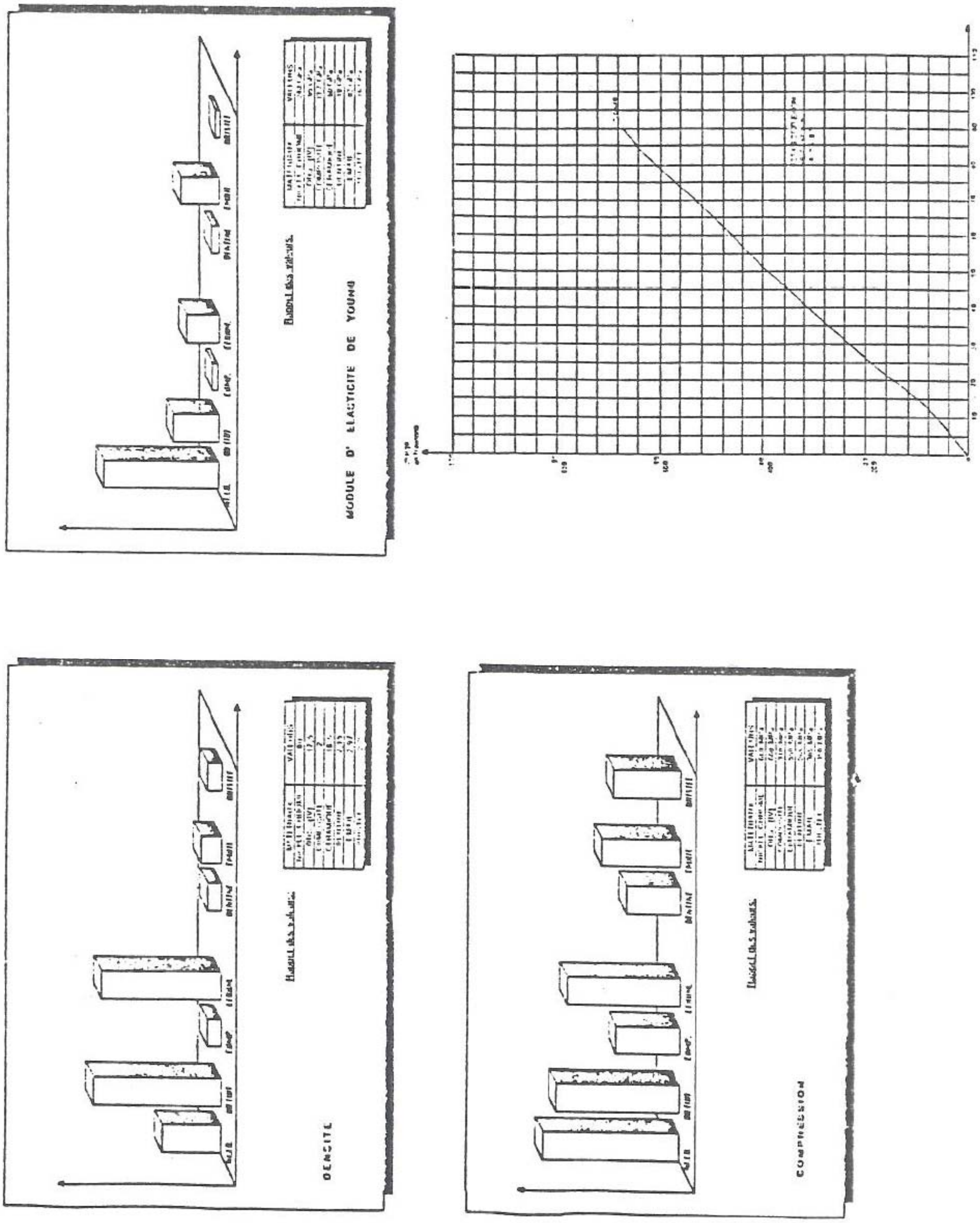


Figure 107

PROPRIETES PHYSIQUES DU MATERIAU

	EMAIL	DENTINE	ARISTEE
- DENSITE	2,9	2,15	2,2
- REFRACTION	-	-	1,6
- P. OPTIQUE	ANNISOTROP	ANNISOTROP	ANNISOTROP
- DILATATION	-	-	11 à 13
- DURETE	93 SHORE D	20 SHORE D	89 SHORE D
- FROTTEMENT	0,2 - 0,6	-	0,3
- ELASTICITE	82 GPa	18 GPa	18 GPa
- COMPRESSION	365 MPa	265 MPa	350 MPa
- FLEXION	-	-	250 MPa
- TRACTION	10 MPa	40 MPa	300 MPa

EMAIL : 92 à 96 % de matiére minérale
8 à 4 % de matiére organique

DENTINE : 66 % de matiére minérale
93 % de matiére organique

ARISTEE (MATERIAU CFAO)

82 à 84 % de matiére minérale
- Fibres
- Cristaux de quartz
- Silice

16 à 18 % de matière organique

certains adhésifs

Figure 108

PROPRIETES PHYSIQUES DU MATERIAU

After having defined the direction and intensity of these forces, we have defined the strength and orientation of the constraints inside the tooth, the prosthesis.

6.2-2.1 Material

We have thus established there should be inside the material privileged orientations of resistance to these constraints. These directions will increase the base values of these specificities of the material. At this stage in our reflexion, we are hit by the following finding:

- how our current techniques oblige us to only use some substances and keep us away from the fundamental subject: make a whole or part of a new tooth!
- how much it appears complex maybe even impossible to copy structures as admirable and mysterious in their finality as dental tissues.

6.3 **Material choice**

From these different studies, three fundamental remarks are to be taken into account for choosing the material:

- enamel represents a heterogeneous structure, with a mineral phase and an organic phase
- its optical properties are very specific
- its very particular physical and mechanical characteristics must be carefully returned by our bio material, statically and dynamically

A rapid examination of the current materials proves that they only one, two or maximum three of their specificities close to those of our specifications. From this reflexion phase, we conclude that a material as complex wouldn't exist in a simple form and that it must be the fruits of a very performing association between different carefully chosen materials. The diversity of characteristics our material must show, their association sometimes contradictory (good attitude in flexion and high hardness), the heterogeneity of the substance loss shows that only one material of an "adaptable" type or more often called "composite" will be capable of uniting in one body such diverse properties. The first dental CAD/CAM material with unitary vocation, that is to say for crown, onlay or inlay will be a composite material with a specific internal multidirectional architecture conceived and realised to answer in all circumstances the different constraints that will apply to the prosthesis.

6.4 Structure and composition

As for any composite material, it will be made up of several distinct materials mixed in several directions, intimately linked with each other, one transmitting to the other the constraints which will apply. About this, it is important to specify in order to avoid regrettable confusion that the charges resins used today in dental prosthesis under the improper name composite material aren't a part of this category of materials, for the simple and good reason that they only have two non oriented components and you must know as well that if the presence of charges increases the resistance to compression, it considerably diminishes the flexion value and the scissoring of the material. It is the opposite of a composite material!!

We distinguish:

- the internal architecture or reinforcement
- the matrix
- the interface
- the charges and additives

6.4-1 Internal architecture

It is of "continuous wire" type, glass fibre E of 9µ of diameter, itself composed of three elementary filaments. It represents 18 to 20% of the material in weight.

The realisation of this architecture needs – as well as a knowhow which is the subject of a patent – an extremely sophisticated and original manufacturing tool. The disposition and orientation of the filament comes as we have described of long dental researches which were essentially about the determination of the directions of the internal constraints of the tooth during the different engagements. This material is already presented like a material specifically dental because of its orientated structure.

This architecture enables the disposition of an aesthetic material with enough adapted mechanical properties. Other elements will reinforce this action, such as charges but we must understand that this architecture and its linking modes with the matrix constitute the originality of this composite material without precedent in dentistry.

To be orientated, crossed, linking with each other, these fibres suffer a first treatment: textile size which makes them supple and able for this type of shaping (figure 105).

6.4-2 Matrix

The architecture itself, without filling material is only a theoretical value. For it to exercise all of its action, it must be included in a support tissue with which it must have extremely strong physico-chemical links.

This matrix must present different "accessibility" criteria.

- compatible with glass architecture and charges
- capable off mechanically flow between the architecture's links during the injection
- affordable
- close to the general properties of our material
- present properties of known bio compatibility

For these reasons, we have chosen a poly-urethane matrix acrylic modified. This low organic fraction of the material (16 to 18%) will correspond to the organic phase of the human enamel and the dentine, while the glass fibre architecture and the charges will correspond to the mineral phase (82 to 84%).

6.4-3 Interface

Of its quality will depend the cohesion between the components, and thus the mechanical value of the material. The performances of our fibrous architecture will only happen if the links with the matrix are solid as through them are transmitted the mechanical constraints of the matrix to the reinforcement. Moreover, during the establishment of the constraints on a composite system, the constituents mustn't be moved otherwise this lack of homogeneity will unavoidably translate by a disaggregation of the material and a fracture.

After shaping the architecture, different operations of sizing and re sizing are done in order to treat the surface of the fibre chemically and mechanically to create an indestructible link during the constraints between the different components.

Only an implementation with highly performing industrial means can help realise this type of links and we understand here the interest of the DENTAL CAD which, by helping us manufacture our own prostheses enables us to finally access this type of material totally unworkable because of the complexity of its implementation, by the current dental techniques applied.

6.4-4 Charges and additives

After having suffered a constant quality control, an antistatic treatment and being silanized, they are mixed to the matrix in a vacuum.

These are essentially:

- glass beads …………………10 to 15μ
- quartz crystals ………………10 to 15μ
- colloidal silica………………100Å

These charges will modulate the mechanical characteristics of the matrix without perturbing the other fundamental values which are insured by the fibrous architecture linked to the matrix.

6.4-5 Additives

Other substances, several additives are also mixed to the matrix before its injection. Their role is very specific.

They are essentially:

- antistatic agents
- inifugeant substances
- links, etc…

whose function is to intervene usefully during the polymerisation.

6.5 **Implementation means**

To realise this type of material, it is necessary to have a production chain in which are reunited both the knowhow and the most performing processes of modern industry in composite materials. It isn't possible to enter here a complete study of this production unit.

6.6 **Coloration and aesthetics**

Different processes of shading of the tooth are currently being used in traditional techniques. None, except the DYCOR, uses the optical properties of a material, for the good and simple reason that all our aesthetical materials don't have the necessary mechanical properties and must be substantiated with metallic infrastructures and to get rid of this metal, we darken their natural transparency. To realise the colour of a tooth, our approach is very clear and we give priority in that order:

- optical properties of the material
- own colour of the material
- subjacent layers colour
- surface coloration

6.6-1 Optical properties of material

Our base research in this domain was on the realisation of a material with the anisotropic optical attitude as close as possible to that of the enamel. We estimated that the fundamental particularity of the shading by the tooth comes from a reflexion, a transmission and a diffusion of the colours of the deep layers (dentine), of the immediate environment (gums), through the dental structures (enamel), themselves coloured.

We have chosen to work our components: matrix, fibrous architecture, charges to get a material with an optical attitude close to that of enamel. The fibrous architecture was totally occulted by the heart penetration of the matrix in the fibres through micropores. Moreover, with its fibres, it plays a very important role by diffusing light inside the material's mass, through a process similar to that of the optical fibres that could be roughly compared to the prisms of human enamel.

The naturally strong translucency of the matrix has been modified by the adjunction of opacifying charges.

6.6-2 Material's own colour

Then we have treated the proper of the material's own colour, thus imitating the different own shades of enamel, colouring our material inside the mass. The material perfectly colours with a pigment so long as the material has been carefully checked before their addition. The material's colour is controlled at all stages of the manufacturing: mixing of the pigments, architecture, charges, pre polymerisation, polymerisation and stabilisation. Four base colours have been chosen, from which the different tones will be realised.

6.6-3 Subjacent layers colour

These different tones are obtained by using lacquer glue whose vivid shades enable us to get the chosen tone on a palette of referenced tones, either empirically or with the help of a colorimeter for those who choose this formula. Here again we only use the optical properties of the material by copying the natural mode that transmits the colours of the dentine through the enamel.

6.6-4 Exceptional alterations

What's left is what we will call exceptional alterations, which, as in nature, escape any logic criteria. We need to intervene manually, artistically this time, by giving the practioner a set of complete dyes which he can put on the surface by photo polymerisation or thermo polymerisation in an oven, or by depositing a varnish highly resistant.

6.6-5 Specificities

Currently, we aren't able to provide the definitive values of the different characteristics of our material. The means used for the implementation aren't the means of a laboratory, in order to make vary the different parameters which happen during the implementation of a product. However, we have done numerous mechanical tests, during the evolution of the material and we are going to communicate the values of the most representative sample of the series.

Two remarks must be done:

- the technological lacks of the laboratory's machine decrease by 25 to 30% the values that we could expect from an industrial implementation
- the tests we made (NF norm of composite material) have been, as is custom, in space's three dimensions, which considerably penalises our material whose preferential strength lines have been chosen for a specifically dental use and with an orientation defined at the start

In the first table, we will bring closer our values to those of the substance loss according to the principal previously stated. Then in order to situate the material with regards to those that exist, we will provide per characteristic, the values of existing materials and ours.

6.7 **CAD pre shape**

To be ready of the digital command manufacturing, it is necessary that the sample be presented in a shape such as it can be manufactured in the best speed and precision conditions. The material sample is "driven" in a resin block, the whole thing constitutes the CAD pre shape.

This pre shape has two parts:

- the noble part
- the prehension resin (figure 109)

6.7-1 Noble part

The noble part is the prosthetic material that we have just described. We will only say that its shape and volume have been calculated so that it is always possible to include all shapes of crowns.

6.7-2 Prehension resin

The prehension resin deserves several remarks and has as well specifications for its function in the CAD chain.

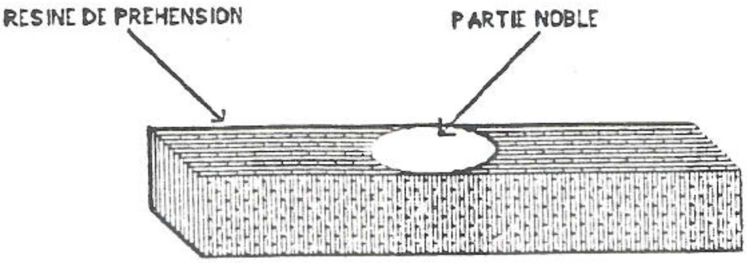
To summarise:

- easy to manufacture
- very resistant to flexion
- compatible with the material's matrix
- affordable
- easy to handle

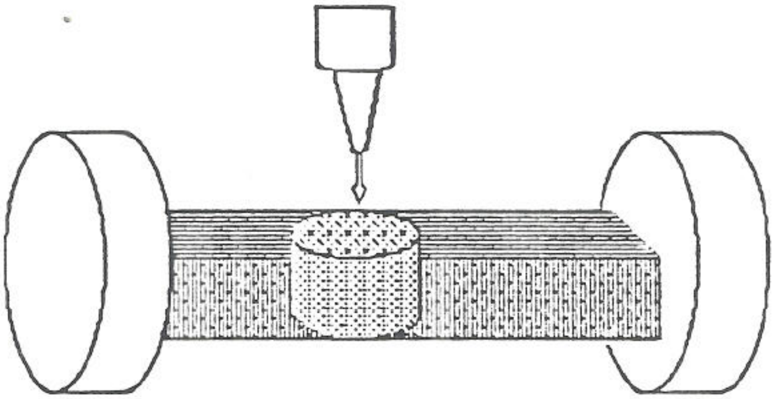
6.8 Conclusion

CAD/CAM applied to dental prosthesis presents in many regards a considerable evolution in a rationalisation of interventions sense and a great rigor in the execution of actions. It isn't daring to say that as the choice and material quality levels, the input is so considerable that it constitutes a sufficient reason of going in the direction of this new prosthetic action conception. The results to this day are only the first step. It isn't doubtful that, freed from current technological constraints we will be able to implement new bio materials, more and more stable, compatible and adapted to our legitimate clinical pretentions. What we had to do was radically change the realisation processes of our prostheses in order to give the realisation of bio materials to highly specialised units offering all the necessary guaranties to get a material conforming in all circumstances with the concerned specifications.

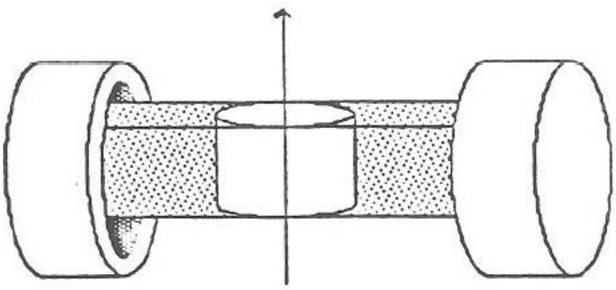
I will add that this opportunity places bio materials at the same rank as state of the art technologies and so it insures the immediate benefit of ulterior more performing discoveries contrary to the current situation where we see bio materials realised with industrial lesser products because of the low interest they represent for big industrial groups. This aspect of the problem has unquestionably played a role in our choice of "adaptable" materials which seem more apt today to insure a true evolution of our product.



LA PREFORME CAO



PREFORME MONTEE SUR LA MACHINE
A COMMANDE NUMERIQUE



LA RESINE DE PREHENSION
SITUE ET ORIENTE LA PARTIE NOBLE
PAR RAPPORT AU POINT O D'USINAGE

Figure 109

6.9 Biocompatibility

This study has for aim to insure the safety and local good tolerance of both materials for dental prosthesis of the composite destined to the realisation of conjoined prostheses with CAD/CAM technique.

Essentially formed of fibres and glass micro beads, as well as a high degree polymerisation resin, the CAD/CAM composite is presented in the shape of a hard mass, insoluble, which, at first hand, has no toxic potential. However, given the large diffusion planned for the CAD/CAM composite, in France as well as abroad, we check the absence of toxic risks through trials on animals, cellular cultures, bacteria as well as clinical trials on humans in real use conditions. Under the name "preliminary trials", we have regrouped three simple and cheap tests. They enable a rapid check of the good local tolerance and the absence of general toxicity of the CAD/CAM composite. In the improbable case of unfavourable results, they would avoid unnecessary and costly trials.

6.8-1 These preliminary trials or phase 1 are:

a) cytotoxicity tests: gelos overimposition method.
This test will be done by Professor ADOLPHE
ECOLE PRATIQUE DES HAUTES ETUDES
15 rue de l'Ecole de Médecine
75006 PARIS

c) implant test on two rabbits according to the USP technique
d) safety trial per bone on 20 male mice and 20 female mice

Given that a systematic toxicity can only be due to substances from the composite and turned into a solution, this trial will be done not with the CAD/CAM composite itself but with liquid extracts of it. For this trial, extraction solvents proposed by the USP have been used. Direct ingestion of the CAD/CAM composite isn't possible even in a pulverised manner as we risk lesions of the digestive tractus, given the hardness of the ingested particles (see phase 3). These trials will be realised by the Company

BIOGIR S.A.
Z.I. DE TOCTOUCAU
33610 CESTAS

Under the responsibility of M. SABOUREAU.

6.8-2 Phase 2

It's about the verification of the absence of allergic risks and muting risks.

- the study of the the sensitisation risks is done on the guinea pig, according to the MAGNUSON technique, by using extraction liquids. This study will be done by the BIOGIR company
- the Ames test will evaluate the muting risk. The technique will be adapted to the insoluble nature of the material. It will be given to Professor MARZIN

INSTITUT PASTEUR DE LILLE

15 rue Camille Guérin
B.P. 245
59019 LILLE CEDEX

If phase 2 gives favourable results, we can start phases 3 and 4.

6.8-3 Phase 3 (toxicity trials on animals)

It includes a local tolerance trail and a general toxicity trial per bone.

- under skin implant on the guinea pig
- local tolerance study on the buccal mucus of the guinea pig
- toxicity study of 14 days on the rat

Even though the composite is destined to stay in the mouth for several years, its absorption is in fact only limited and accidental, it doesn't seem necessary to do long term toxicity trials. These 3 trials are done by BIOGIR.

6.8-4 Phase 4 (clinical trial)

The protocol for this trial will be inspired by the ISO/TR 1984 norm, biological evaluation of dental products, paragraph 6.14, trials on pulp and dentin of restoration products. It would be interesting to complete the study by an electronic microscopy examination of some tooth/crown slices, to show the regularity of the junction between the stump and the crown. But such a study seems unlikely as because of the hardness of the CAD/CAM composite. It has been done and shown in several congresses. This trial being done on humans, there won't be negative witness teeth and even less positive witness teeth.

Even though the ISO/TR 7405 – 1984 norm offers the possibility of realising this tolerance trial on pulp and dentin on a monkey, we prefer human trials, which seem closer to real use conditions, the intolerance risk being very low because of the nature of the material tested. Moreover, a study on a monkey would necessitate including all monkey data in the CAD/CAM computer for the realisation of a prosthesis!

We are thinking of doing a study on 50 patients in two centres. No clinical expert has been chosen yet.

It doesn't seem necessary to check the attitude of the CAD/CAM composite after it has been submitted to X rays. The ionising radio doses it can receive during x rays on a patient are ridiculously low with regards to those during its manufacturing.

LEXIQUE INFORMATIQUE

A TERMES SPÉCIFIQUES	DÉFINITION
ACCES	Les données, qui se trouvent dans les fichiers* peuvent être exploitées par l'ordinateur* si celui-ci y accède. Il existe 3 grandes méthodes d'accès : accès séquentiel, accès direct et accès indexé.
ACCES SEQUENTIEL	On dit qu'on accède séquentiellement à un enregistrement* si, pour le trouver, il faut être «passé» sur tous ceux qui le précédaient. Ex. : sur un magnétophone, le troisième enregistrement ne peut être lu qu'après qu'on ait lu les deux premiers (voir SEQUENTIEL, FICHIER SEQUENTIEL).
ACCES DIRECT	L'accès à un enregistrement* se fait directement quand on connaît l'endroit exact où il se trouve. Lorsque vous posez le bras du tourne-disque directement sur le morceau qui vous intéresse, vous faites de l'accès direct (voir FICHIER DIRECT).
ACCES INDEXE	Pour accéder à un enregistrement, on utilise un «index» qui indique «l'adresse»* de l'enregistrement*. Ex. : le chapitre sur le système solaire se trouve à la page 22 du tome 4 de l'encyclopédie. Cette méthode combine l'avantage de l'accès direct (plus rapide) et de l'accès séquentiel (peu de perte de place). (voir FICHIER INDEXE, INDEX).
ADI	Service du Ministère de l'Industrie chargé de tous les problèmes de l'informatique.
ADIRA	Association pour le Développement Informatique Rhône-Alpes (formation, clubs, conférences, ...).
ADRESSE	Localisation d'une donnée en «mémoire centrale»* ou en «mémoire auxiliaire»*.
ALEATOIRE	– «Au hasard» – Se dit d'un fichier dans lequel les enregistrements* sont stokés sans ordre préétabli.
ALGOL	Langage* de programmation*
ALGORITHME	«Processus de calcul permettant d'arriver à un résultat final déterminé». Par extension, c'est la description précise de la méthode à employer pour arriver à un certain résultat. Ex. : pour ajouter deux nombres, il faut connaître l'algorithme de l'addition qui précise tous les détails de l'opération (tables, règles de retenue, etc...).
ANALYSE	Etude détaillée d'un ensemble consistant à décomposer celui-ci en ses plus petits principes constituants.

** L'astérisque qui suit certains termes portés dans la colonne «Définition» signifie que ces termes sont explicités, par ordre alphabétique, dans le présent Lexique.*

ANALYSE FONCTIONNELLE	Relève de la technique de l'organisation des données* et de leur traitement*.
ANALYSE ORGANIQUE	Technique de l'analyste-programmeur qui traduit l'analyse fonctionnelle dans le langage choisi et en fonction du matériel et de son «logiciel de base»*. Précède la programmation même (voir PROGRAMMATION).
ANALOGIQUE	Quand une information est représentée par une valeur susceptible de varier de façon CONTINUE, comme par exemple la tension aux bornes d'un microphone, on dit que c'est une information analogique. Pour qu'un ordinateur puisse utiliser une telle information, il faut la numériser : cette opération s'appelle la conversion analogique-numérique. (voir DIGIT). La conversion transforme le signal analogique en digit* binaire*.
ANSI	Organisme américain de normalisation.
APPLICATION	Fonction, dans l'entreprise, regroupant de manière cohérente des travaux effectués en vue d'obtenir un résultat simple, à laquelle on applique la méthode d'organisation informatique des données. Ex. : application «gestion de stock». L'ensemble des application forme le «système général de traitement des informations»* de l'entreprise.
ARCHITECTURE	Façon d'organiser les éléments d'un système* entre eux (Voir Fiche I.3).
ARTICLE	Groupe de données constituant une unité par rapport à un traitement déterminé. Par exemple, dans un logiciel de gestion, chaque client constitue un article.
ASCII	Table de traduction. Le Code ASCII permet de définir des caractères (lettres, chiffres, ponctuation) en les codant sur 7 bits. On l'utilise dans les échanges entre ordinateur* et périphériques*. En lui ajoutant un huitième bit*, chaque caractère est traité comme un octet*.
ASSEMBLEUR	Langage de programmation symbolique* très proche du langage machine.
AUDIT	Contrôle du bon fonctionnement d'un système*.
AUTOMATISME	Liaison d'un automate avec un ordinateur destinée à lui faire exécuter, dans des situations diverses, les opérations prévues dans un programme. (voir ROBOT, ROBOTIQUE).
AUTOMATE	Voir ROBOT

B

BANDE MAGNETIQUE	Support magnétique de données sur bande, de grande capacité, à «accès séquentiel»* uniquement, constitué d'un ruban de matière plastique souple recouvert, sur une face, d'une touche magnétisable.
BANQUE DE DONNEES	Ensemble de collections de données, c'est-à-dire de fichiers voisins ou apparentés, mis à la disposition du public.
BASE DE DONNEES	Système d'organisation des données sur disque indépendant de l'organisation des traitements. Le lien entre base et traitements se fait par le SGBD*.
BASIC	Langage de programmation* le plus répandu pour les «ordinateurs individuels»*. Il est à la fois évolué et facile à apprendre. Les instructions de base sont rédigées en Anglais.
BATCH	Traitement des données* par l'ordinateur* sous forme de «lots», effectué avec un décalage plus ou moins important dans le temps par rapport à la saisie* des informations, et sans intervention de l'utilisateur. (Contraire : traitement interactif). Ex. : augmentation et édition d'un tarif. (Voir Fiche I.3.

BAUD	– Unité de vitesse de modulation. – Assimilable dans certains cas à une vitesse de transmission. (1 baud = 1 bit/seconde)
BINAIRE	Le code* binaire utilise le système de calcul en base 2, qui ne comporte que deux états : Ø et 1.
BIT	Elément d'information qui peut prendre deux valeurs arbitrairement notées Ø et 1. Abréviation de «binary digit»* : chiffre binaire.
BUFFER	Mémoire-tampon assurant l'échange entre «l'unité centrale»* et un périphérique*.
BUG	Tout programme* que l'on vient d'écrire comporte – hélas – des bugs, c'est-à-dire des erreurs qui l'empêchent de fonctionner correctement.
BULLE	Surface de 3 microns environ constituée d'un matériau qui a la propriété de se magnétiser très localement sous l'action d'un champ magnétique. Les mémoires à bulles sont des mémoires permanentes de grande capacité.
BUREAUTIQUE	– Utilisation conjuguée de nouvelles techniques pour faciliter les travaux de bureau : traitement de texte, courrier électronique, tableurs, gestion de fichiers, graphiques. – Etude des changements ainsi apportés dans les secrétariats.
BUS	Ensemble de signaux permettant au processeur* de converser avec ses mémoires et ses périphériques. Ils sont véhiculés dans le canal.* Certains bus sont normalisés et utilisés par de nombreux micro-ordinateurs : S-100, IEEE 488, ... (Voir CANAL).
BYTE	Ensemble de 8 bits correspondant à 1 caractère (voir OCTET).

C

CAHIER DES CHARGES	Document à caractère contractuel définissant précisément les fonctions d'un système informatique à installer. ((Voir Fiche I.5).
CANAL	Appareil assurant l'échange de données* entre la mémoire centrale et les périphériques (Voir BUS).
C A O	Conception Assistée par Ordinateur. Matériel et logiciel orientés vers l'assistance à la conception pour les bureaux d'étude.
CARTE	Plaque supportant des «composants électroniques»* assemblés en circuit.
CASSETTE	«Bande magnétique»* de petite et moyenne capacité, enfermée dans un container facilitant sa conservation et sa manipulation.
CATALOGUE	Voir LIBRAIRIE
C C D	Composant photo-électrique utilisé dans les caméras reliées à des ordinateurs.
CENTRE SERVEUR	Ordinateur* pouvant être interrogé par un utilisateur éloigné disposant d'un terminal*. (Voir Fiche Videotex).
CHAINE DE CARACTERES	Succession de caractères formant un ensemble intelligible. (Voir CONCATENATION).
CIRCUIT IMPRIME	Dépôt métallique conducteur placé sur un support isolant pour constituer des éléments plans de câblage ou pour créer des éléments plans de circuit dans un schéma général de câblage.

CIRCUIT INTÉGRÉ	Se présente sous la forme d'un petit boîtier muni de deux rangées de pattes métalliques. Dans ce boîtier se trouve une pastille de silicium de quelques millimètres carrés dans laquelle sont diffusés des transistors*, des diodes* et des résistances formant une fonction électronique complexe miniaturisée. (Voir PUCE).
CLE D'ACCES	Critère de recherche dans un «fichier indexé»*. Ex. : dans un fichier indexé sur le code client, la clé d'accès sera le code client.
COBOL	Langage* de programmation* très orienté vers les applications* de gestion.
CODE	Système* de symboles* permettant de représenter une information*. Ex. : code ASCII, code client.
CODE BARRES	Code* décryptable par lecture optique, basé sur l'utilisation de barres de largeur et d'espacement divers imprimées sur des étiquettes, permettant l'identification d'un objet.
COMPATIBLE	– Un périphérique* est compatible avec un ordinateur* si on peut les connecter sans difficulté. – Deux ordinateurs* sont compatibles si les programmes* écrits pour l'un fonctionnent correctement sur l'autre.
COMPILATEUR	Programme permettant de traduire en «langage machine»* (binaire*) un programme écrit en «langage évolué»* (Basic, Cobol ...) et ainsi de l'exécuter. Il traduit le «programme source»* en «programme OBJET»* exécutable. Il y a donc dans les fichiers deux programmes : le programme SOURCE écrit par le programmeur et proche du langage humain, le programme OBJET traduit par le compilateur et exécutable par la machine.
COMPOSANT ELECTRONIQUE	Constituant élémentaire d'un circuit (Transistor*, diode* ...).
CONCATENATION	Assemblage de plusieurs «chaînes de caractères»* constituant un ensemble intelligible.
CONFIGURATION	Ensemble des matériels* constituant l'infrastructure d'un système informatique de traitement des informations. (Voir Fiche I.3).
CONFLIT D'ACCES	Lorsque deux utilisateurs veulent intervenir simultanément sur la même donnée, il y a conflit d'accès.
CONTROLE DE PARITE	Bit de position 1 rajouté lors de l'écriture d'un caractère lorsque le nombre de bits de position 1 correspondant à celui-ci est impair. A la lecture, un contrôle basé sur la vérification de la parité des bits de position 1 permet de déceler toute anomalie. (Voir BYTE, BIT).
CONTROLEUR	Organe permettant à l'ordinateur* de contrôler un périphérique*. Ex. : le contrôleur de disquettes* est un ensemble de circuits permettant à l'ordinateur de commander «l'unité de disquettes»* et de dialoguer avec elle.
CONVERSATIONNEL	Voir INTERACTIF
CORRESPONDANT INFORMATIQUE	Personne, dans une entreprise, assurant la liaison entre les informaticiens et les utilisateurs.
CP/M	«Système d'exploitation»* de disquettes» très répandu (SED) : les ordinateurs individuels utilisant CP/M sont, en principe, compatibles, même s'ils sont de marques différentes.
C P S	Caractères Par Seconde
C P U	Control Processing Unit : Unité centrale comprenant le micro-processeur et la mémoire centrale.
CRASH	Panne Système (= panne de matériel)
CRYPTOGRAPHIE	Chiffrage des informations pour en assurer la confidentialité.

D

DATA	Mot anglais = DONNEE
DATA BASE DBMS	«Base de données»* (Voir SGBP).
DEBIT	Vitesse de transfert dans un canal*
DESSIN D'ENREGISTREMENT	Définit, dans l'enregistrement, une place précise et inaliénable à chaque zone (voir ZONE).
DIDACTICIEL	Logiciel* spécialisé pour l'enseignement.
DIGIT	Elément d'information* qui peut prendre un nombre fini de valeurs différentes. Ex. : code binaire*.
DIODE	«Composant électronique»* à base de semi-conducteurs = Redresseur de courant. (Voir SEMI-CONDUCTEUR).
DIRECTORY	Voir LIBRAIRIE.
DISQUE AMOVIBLE	Disque interchangeable
DISQUE DUR	Disque magnétique de grande capacité (10 à 300 millions de caractères) tournant à vitesse élevée (2.400 t/m).
DISQUE FIXE	Non interchangeable (Voir WINCHESTER).
DISQUE SOUPLE	Disquette*
DISQUETTE	Disque souple, amovible, de petite taille (3,5, 5,8 pouces*), de faible capacité (100.000 à 3 millions de caractères)' enfermé dans une enveloppe de protection fixe à la manière d'une cassette* de bande magnétique.
DONNEE	Forme donnée à l'information*, lors de la saisie, destinée à faciliter son traitement par l'ordinateur. (Voir SAISIE).
DOS	Disk Operating System. – Est un «système d'exploitation»*.

E

EAO	**E**nseignement **A**ssisté par **O**rdinateur. Utilisation pédagogique de l'ordinateur où celui-ci joue le rôle de répétiteur ou de simulateur permettant de tester les différentes réactions de l'élève.
EBCDIC	Table de traduction. Le code EBCDIC permet de définir des caractères en les codant sur 8 bits*.
ELECTRONIQUE	Technique utilisant les variations de grandeur électrique pour capter, transmettre et exploiter de l'information.
EMULATEUR	Dispositif permettant de simuler, sur un appareil, le fonctionnement d'un autre appareil.
ENREGISTREMENT	Est constitué par un ensemble d'informations élémentaires ayant un lien logique entre elles. Ex. : Code client, raison sociale, adresse : cet enregistrement regroupe 3 informations de ce type (Voir ZONE, DESSIN, FORMAT, LONGUEUR). N.B. – Il est plus exact de dire : «données»* à la place d'informations, lorsqu'on parle du contenu d'un enregistrement.
EPROM (ou REPROM)	**E**rasable **P**rogrammable **R**ead **O**nly **M**emory – Mémoire électronique reprogrammable et effaçable.

EXPLOITATION	Ensemble des opérations liées à l'utilisation d'un ordinateur.

F

F A O	**F**abrication **A**ssistée par **O**rdinateur.
FICHIER	Ensemble de données* de même nature stockées sur un support quelconque: fiches cartonnées, cassettes, disques... Un fichier est caractérisé par la nature de son support, son volume, ses modes d'accès*, sa fréquence d'utilisation. Les données sont réparties dans les enregistrements*.
FICHIER ALEATOIRE	Voir ALEATOIRE
FICHIER DIRECT	Fichier à «accès direct»* grâce à la connaissance de l'adresse* (ou localisation) exacte de l'enregistrement.
FICHIER INDEXE	Fichier à «accès indexé» grâce à l'adjonction au fichier d'un index*, sorte de table des matières permettant de retrouver l'adresse* de l'enregistrement.
FICHIER RELATIF	Accès par la position de l'enregistrement* par rapport au début du fichier*.
FICHIER SEQUENTIEL	Fichier à «accès séquentiel»*, qu'on lit intégralement depuis le début jusqu'à ce qu'on rencontre l'enregistrement* cherché.
FILE D'ATTENTE	Données* provenant des terminaux*, stockées en attente de traitement par l'ordinateur (ordinateur multi-poste, télématique*). (Voir CENTRE SERVEUR).
FIRMWARE	Mot anglais : «logiciel de base»* du constructeur.
FLOPPY	Mot anglais : disquette*
FORMAT D'UN ENREGISTREMENT	Constitué par le dessin et la longueur de l'enregistrement. (Voir DESSIN, LONGUEUR).
FORMATER	1ère opération à effectuer lors de l'utilisation d'un disque vierge : consiste à demander à l'ordinateur de préparer le disque afin qu'il soit utilisable par celui-ci en fonction de son propre système d'exploitation.
FORTH	Langage* de programmation* très structuré.
FORTRAN	Langage* de programmation* évolué adapté principalement aux utilisations scientifiques.
FRONTAL	Ordinateur* gérant les terminaux* et les «files d'attente»*.

G

GENERATEUR	Programme* permettant de créer plus facilement d'autres programmes.
GESTIONNAIRE D'APPLICATION	Progiciel* directement utilisable pour réaliser une application* sans faire appel à un programmeur.
G P A O	**G**estion de **P**roduction **A**ssistée par **O**rdinateur. Matériel et logiciel adaptés à la Gestion de Production.

H

HARDWARE	Mot anglais : quincaillerie. Employé pour : matériel* informatique. (abr. : HARD).

HEXADECIMAL	Système de numération en base 16 dans lequel on utilise les chiffres de 0 à 9 puis les lettres de A à F. Par exemple 10 en décimal s'écrit A en hexadécimal; 17 en décimal s'écrit 11 en hexadécimal.
HORLOGE	Dispositif électronique permettant de synchroniser le fonctionnement du micro-processeur*.

I

INDEX	Table classée permettant un accès rapide aux données* d'un fichier*.
INFORMATIQUE	Traitement* automatique et rationnel de l'information* considérée comme support de la connaissance et de la communication.
INFORMATION	Indication permettant la connaissance d'une chose.
INITIALISATION	Procédure* de mise en route.
INPUT / OUTPUT	Mot anglais : Entrée / Sortie
INTÉGRÉ	– Se dit d'un système de traitement* où toutes les applications* sont reliées les unes aux autres. – Se dit d'un logiciel* contenant tableur*, gestion de fichiers, traitement de texte*, graphiques.
INSTRUCTION	Ordre, consigne, précis exprimé dans un langage* de programmation*.
INTERACTIF	Se dit d'un traitement* permettant une conversation entre l'ordinateur* et l'utilisateur. Les informations* sont traitées pas à pas grâce au dialogue homme-machine. Ex. : saisie d'une commande. (Contraire : BATCH*). (Synonymes TEMPS REEL*, CONVERSATIONNEL*).
INTERFACE	– Ensemble matériel* et logiciel* nécessaire pour assurer la communication entre un périphérique* et un ordinateur*. – Programme* permettant de relier deux applications*. Ex. : facturation et comptabilité.
INTERPRETEUR	Programme* qui traduit un programme écrit en «langage évolué»*, au fur et à mesure du déroulement de celui-ci, en langage machine, permettant ainsi son exécution (Comparer avec COMPILATEUR).
ITEM	Mot anglais : ARTICLE*

K

K (ou Koctets ou Kbytes)	Unité de capacité mémoire : 1024 octets.
K UTILISATEUR	Capacité mémoire du matériel réellement disponible pour l'utilisateur.

L

LANGAGE	Mode de transmission de l'information*.
LANGAGE ÉVOLUÉ	Langage* proche de la logique humaine (traduit en langage machine par un compilateur ou un interpréteur. Exemples : Basic, Fortran, Cobol, Pascal, APL, Pilot, Forth, Lisp, Logo, LSE ...). (Voir Fiche I.2).
LANGAGE INFORMATIQUE	Ensemble de caractères, de symboles* et de règles permettant de les assembler, utilisé pour rédiger les instructions* à donner à un ordinateur*.

LANGAGE MACHINE	Le langage machine est le seul que comprenne directeur un ordinateur*. Il est exprimé en code* binaire*.
LANGAGE SOURCE	Voir PROGRAMME-SOURCE
LIBRAIRIE	Liste du contenu d'un disque magnétique
LIGNE SPÉCIALISÉE	Ligne téléphonique réservée spécialement à l'acheminement des données* informatiques par un seul et même utilisateur. (Voir MULTIPLEXEUR).
LISTE LISTING LISTAGE	Etat informatique imprimé.
LOGICIEL	Programme* ou ensemble de programmes.
LOGICIEL D'APPLICATION	Programme* de l'utilisateur lui permettant d'assurer ses traitements*.
LOGICIEL DE BASE	Fabriqué par le constructeur et livré avec l'ordinateur*, il permet de faire fonctionner celui-ci.
LOGICIEL INTÉGRÉ	Voir INTÉGRÉ
LOGICIEL SPÉCIFIQUE	Se dit de programmes* conçus spécialement pour une application*, par opposition à PROGICIEL*.
LONGUEUR D'UN ENREGISTREMENT	Se calcule en nombre de caractères par addition des caractères contenus dans chaque zone de l'enregistrement. (Voir ZONE, VOLUME).
LUDICIEL	Logiciel* de jeu.

M

MATÉRIEL	Ce terme revêt une signification précise dans le contexte informatique, par opposition à son autre composante : le logiciel*. Il désigne l'ensemble des pièces mécaniques et des «composants électroniques». (cf. HARDWARE et SOFTWARE).
MÉMOIRE	Organe qui permet de stocker, dans l'unité centrale* ou en dehors d'elle, une information* afin de l'utiliser ultérieurement.
MÉMOIRE AUXILIAIRE	Est constituée par toutes les «mémoires rémanentes»* externes à «l'unité centrale»*, capables de stocker des données* : bandes magnétiques, cassettes, disques, disquettes ... (voir Fiche I.2).
MÉMOIRE CENTRALE	Mémoire électronique, volatile (voir MÉMOIRE VOLATILE) installée dans «l'unité centrale»* de l'ordinateur*.
MÉMOIRE ELECTRONIQUE	Constituée de «composants électroniques» susceptibles de présenter deux états : chargé, non chargé, traduisant ainsi le code binaire* et représentant un bit*. Toute coupure électrique ramène les composants à l'état neutre et vide la mémoire (Voir MÉMOIRE VOLATILE).
MÉMOIRE MAGNÉTIQUE	Constituée d'éléments microscopiques de matière magnétisable par aimantation sous l'effet d'un champ magnétique. Chaque élément est susceptible d'avoir deux états : aimanté, non aimanté, traduisant ainsi le code binaire* et représentant 1 bit*. Un élément reste aimanté après coupure de l'alimentation électrique (Voir MÉMOIRE RÉMANENTE).
MÉMOIRE DE MASSE	Voir MÉMOIRE AUXILIAIRE
MÉMOIRE MORTE	«Mémoire électronique»* que l'on ne peut que lire (voir ROM et EPROM).

MÉMOIRE PERMANENTE	Voir MÉMOIRE RÉMANENTE.
MÉMOIRE RÉMANENTE	Caractéristique d'une mémoire composée de supports magnétiques : les données qu'elle contient ne sont pas détruites par la coupure de l'alimentation électrique. C'est une mémoire permanente. (Contraire : MÉMOIRE VOLATILE).
MÉMOIRE VIRTUELLE	Se dit d'une technique de gestion dynamique de la «mémoire centrale»* permettant l'exécution rapide de plusieurs programmes* simultanément. La mémoire centrale est partagée en cadres de taille égale qui recevront chacun un bloc correspondant extrait de chaque programme. Une «mémoire auxiliaire»* stocke momentanément les autres blocs (ou «pages») des programmes. Chaque bloc exécuté est remplacé dans la mémoire centrale par le bloc suivant. «L'unité centrale»* travaillant beaucoup plus rapidement que les périphériques*, l'utilisateur a l'impression que les programmes s'exécutent simultanément alors qu'en fait, ils s'exécutent par intercalements successifs des blocs. La mémoire nécessaire au stockage de tous les programmes, s'ils s'exécutaient simultanément, étant beaucoup plus grande que la mémoire réelle centrale, cette technique donne l'illusion d'une mémoire virtuelle.
MÉMOIRE VIVE	«Mémoire électronique»* que l'on peut lire, effacer, charger à volonté.
MÉMOIRE VOLATILE	Caractéristique d'une «mémoire électronique». Les données qui s'y trouvent sont détruites par toute coupure de l'alimentation électrique. C'est une mémoire temporaire. (Contraire : MÉMOIRE RÉMANENTE).
MICRO-ORDINATEUR	Ordinateur* de faible volume dont l'unité centrale* de traitement arithmétique et logique est constituée par un micro-processeur»*;peut être multiposte. (Comparer ORDINATEUR INDIVIDUEL).
MICRO-PROCESSEUR	«Circuit intégré»* très complexe regroupant les logiques de traitement*, qui a permis l'apparition des «ordinateurs individuels»*. C'est un processeur très miniaturisé (voir PROCESSEUR). (Voir MICRO-ORDINATEUR).
MINIDISQUETTE	Voir DISQUETTE.
MINITEL	Terminal*, standard permettant d'accéder à des «centres serveurs»*. VIDEOTEX
M.O.	1 Million d'Octets.
MODEM	Abréviation de : «modulateur - démodulateur». Appareil permettant la transmission des «données» par une ligne téléphonique ordinaire. Voir Fiche I.3).
MODULATION	Convertit les données informatiques codées en langage numérique, en données codées en langage analogique* seul accepté par les modes de transmission des réseaux.
MONITEUR	Programme* créé par le constructeur, chargé de surveiller le fonctionnement de la machine et des programmes. (logiciel de base).
MONITEUR VIDEO	Ecran cathodique relié à l'ordinateur*, et permettant de visualiser les instructions* ou les informations*.
MONO-PROGRAMMATION	Un micro-processeur* ne peut exécuter qu'une seule instruction à un instant donné, et donc un seul programme* ou une seule séquence de programme : c'est la mono-programmation. Par opposition, la multi-programmation est une technique d'exploitation* permettant d'exécuter simultanément plusieurs programmes.
MOT	Groupe de caractères ou de bits* occupant une seule position mémoire dans l'ordinateur* (8, 16 ou 32 bits).
MOT-CLÉ	Mot caractérisant sans équivoque l'information* contenue dans un texte d'une «banque de données»*.

MOT DE PASSE	Code personnel autorisant l'accès à certains traitements.
MS - DOS	«Système d'exploitation»* standard sur micro 16 bits.
MULTIPLEXEUR	Permet de connecter plusieurs utilisateurs sur une même ligne de transmission spécialisée. (Voir LIGNE SPÉCIALISÉE).
MULTI-PROGRAMMATION	Voir MONO-PROGRAMMATION.

N

NANO-SECONDE	1 milliardième de seconde.

O

OCTET	Ensemble de 8 bits*, permettant de stocker des valeurs entières de 0 à 255. Correspond à un caractère. (En anglais : BYTE).
ONDULEUR	Appareil permettant de pallier les incidents d'alimentation électrique (coupures et micro-coupures).
O E M	**O**riginal **E**quipment **M**anufacturer. Sociétés spécialisées dans la vente de solutions clés en main (matériel* + logiciel*) faisant souvent appel à l'assemblage de matériels d'origines diverses.
ORDINATEUR	Au sens restreint, l'ordinateur est une machine programmable de traitement* de l'information* composée uniquement de «l'unité centrale»*. Il a besoin, pour être exploitable, de périphériques* divers selon l'utilisation que l'on veut en faire.
ORDINATEUR INDIVIDUEL	Ordinateur monoposte (1 seul écran clavier) construit autour d'un microprocesseur*. (Voir MICRO-ORDINATEUR).
ORDINOGRAMME	Traduction graphique d'un algorithme*, de l'expression d'une suite logique d'actions. Plus précisément : schéma représentant graphiquement le déroulement d'un programme* au moyen de symboles* normalisés.
ORGANIGRAMME	Même sens que ordinogramme, en informatique.

P

PACK	Concerne uniquement le chargement d'informations numériques dans les enregistrements* : consiste à mettre deux chiffres dans un seul octet pour gagner de la place. La zone de l'enregistrement concernée est dite packée.
PACKAGE	Voir PROGICIEL.
PARTITION	Partie de la «mémoire centrale* réservée à un utilisateur ou un programme*. Il peut y avoir plusieurs utilisateurs ou programmes, donc plusieurs partitions. (Voir MULTI-PROGRAMMATION et MÉMOIRE VIRTUELLE).
PASCAL	Langage* de programmation évolué.
PÉRIPHÉRIQUE	Appareil permettant d'entrer des informations dans l'ordinateur* ou de les en sortir (ENTRÉE / SORTIE) : clavier, «moniteur vidéo»*, imprimantes, «mémoires auxiliaires»*. (Voir Fiche I.2).

PLAN INFORMATIQUE	Projet d'informatisation d'une ou plusieurs applications* décrivant le système de traitement souhaité et l'évolution des moyens informatiques à mettre en œuvre dans le temps, accompagné du budget correspondant.
PL 1	Langage* de programmation* IBM.
PORTABLE	Micro-ordinateur transportable, mais sans alimentation électrique autonome.
PORTATIF	Micro-ordinateur de taille et de poids réduits alimenté par piles ou batteries.
POUCE	Mesure anglo-saxonne : 25,4 m/m.
PROCÉDURE	Méthode utilisée pour atteindre un certain résultat.
PROCESSEUR	Organe capable d'assurer le traitement* complet d'une série de données*. (Voir MICRO-PROCESSEUR).
PROGICIEL	Logiciel* complet et documenté conçu pour une application* concernant un certain nombre d'utilisateurs différents, acheteurs potentiels. Ex. : progiciels de comptabilité, progiciels de gestion de stock de quincaillerie, progiciels de gestion de pharmacie... Moins chers qu'un logiciel spécifique, ils mettent l'informatisation à la portée du plus grand nombre. Certains progiciels peuvent recevoir des adaptations leur permettant de correspondre au plus près aux besoins des utilisateurs. (En anglais : PACKAGE).
PROGRAMMATION	Rédaction des programmes* d'instructions destinés à obtenir de l'ordinateur* les résultats demandés par l'utilisateur.
PROGRAMME	Ensemble des instructions* rédigées dans un langage* donné (en «langage évolué»* la plupart du temps), et que doit exécuter l'ordinateur. Ex. : programme en basic calculant les payes d'une entreprise. Par extension, on parle d'un «programme de paye».
PROGRAMME OBJET	Programme en langage machine directement exécutable.
PROGRAMME SOURCE	Programme, en langage évolué, non directement exécutable par la machine. Le compilateur* ou l'interpréteur* le traduisent en programme objet *.
PROLOGUE	«Système d'exploitation»* français.
PROM	Mémoire PROM (**P**rogrammable **R**ead **O**nly **M**emory). Livrée vierge, cette mémoire, une fois programmée par l'utilisateur, devient une mémoire ROM. (Voir ROM).
PUCE	Petite surface de silicium incorporée dans un «circuit intégré» et dans laquelle a été réalisée la logique du circuit. (Voir CIRCUIT INTÉGRÉ).

R

RAM	Mémoire RAM (**R**andom **A**ccess **M**emory). (Voir MÉMOIRE VOLATILE).
RACK	Meuble ou boîtier permettant d'enficher des cartes. (Voir CARTE).
RANDOM	Signifie : aléatoire.
RÉALISATION	Regroupe «analyse organique»* et programmation*. On parle de la réalisation d'une application.
RÉPERTOIRE	(Voir LIBRAIRIE).
RÉSEAU	Ensemble des lignes de transmission connectant des terminaux* à un ordinateur* central.

RÉSEAU LOCAL	Connexion de plusieurs ordinateurs ou micro-ordinateurs au sein d'un même établissement.
RÉSEAU COMMUTÉ	Lignes téléphoniques normales. Peuvent être utilisées pour transmettre des données* si elles passent par des centraux automatiques. (Voir LIGNE SPECIALISÉE).
RÉSEAU TRANSPAC	Réseau spécifique des transmissions de données constitué d'un ensemble d'ordinateurs spécialisés reliés entre eux par des liaisons à grande vitesse.
RÉSIDENT	Tout ce qui est à l'intérieur de la «mémoire centrale»* à un moment donné.
ROBOTIQUE	Ensemble des études et des techniques tendant à concevoir des systèmes* capables de se substituer à l'homme dans ses fonctions motrices, sensorielles et intellectuelles. (Voir AUTOMATISME).
ROBOT	Appareil capable d'agir de façon automatique pour une fonction donnée. (Voir AUTOMATISME, ROBOTIQUE).
ROM	Mémoire ROM (**R**ead **O**nly **M**emory). Ne peut être que lue.
ROUTINE	Terme anglais francisé désignant : programme ou sous-programme.
RS 232 C	Norme fixant les caractéristiques du type de transmission utilisé pour relier un ordinateur* à un périphérique.

S

SAISIE	Transcription des informations sous forme codée sur un support normalisé (carte perforée, disque...) en vue de leur traitement : la saisie transforme une information en donnée*. (Voir DONNÉE).
SAISIE DIRECTE	Appelée aussi «ON-LINE». Met directement en relation l'appareil de saisie* avec le fichier-maître.
SAISIE INDIRECTE	Appelée aussi «OFF-LINE». Met l'appareil de saisie en relation avec un fichier intermédiaire de stockage (cartes perforées, documents à lecture optique, disquettes, bandes magnétiques) qui sera lu ensuite par l'ordinateur principal et stocké dans le fichier maître.
SAUVEGARDE	Les supports magnétiques étant effaçables accidentellement, ou destructibles, il convient d'effectuer périodiquement des copies de leur contenu et de sauvegarder celles-ci dans un lieu adéquat.
SEMI-CONDUCTEUR	Les matériaux semi-conducteurs ont une conductibilité qui se situe à mi-chemin de celle des conducteurs et celle des isolants. Par l'apport de corps étrangers, ils acquièrent des propriétés spécifiques qui permettent de réaliser transistors*, diodes*, circuits intégrés*.
SEQUENTIEL	Consécutif
SERVEUR	Ordinateur gérant une «banque de données»* accessible par MINITEL ou par d'autres ordinateurs.
SÉLECTION	Signifie CHOIX (ne pas confondre avec TRI).
S G B D	**S**ystème de **G**estion de **B**ase de **D**onnées. Pour une «base de données»*, c'est le logiciel* qui permet d'introduire les données*, de les mettre à jour et d'y accéder. (En anglais : DBMS : **D**ata **B**ase **M**anagement **S**ystem).
SOFTWARE	Mot anglais : logiciel (abr. SOFT).
SOURIS	Dispositif s'apparentant à une poignée et permettant de désigner un point de l'écran en positionnant un curseur sur l'emplacement désiré.

SPÉCIFIQUE	Voir LOGICIEL SPÉCIFIQUE
SPOOL	Fichier d'édition différée, sis en «mémoire auxiliaire»* et généré par le «système d'exploitation»*. Stocke les données* issues d'un traitement*, en attention, d'impression
S S I I	Société de Service d'Ingénierie Informatique
SYMBOLE	Signe conventionnel abréviatif.
SYSTEME	Combinaison d'éléments qui se coordonnent pour parvenir à un résultat.
SYSTEME EXPERT	Intelligence artificielle. Ordinateur capable d'exploiter l'acquis historique qu'est l'expérience associée à la mémoire chez l'homme. Le système appelé aussi ordinateur de la 5e génération, en est au stade de la recherche.
SYSTEME D'EXPLOITATION	Voir LOGICIEL DE BASE et Fiche I.2.
SYSTEME GÉNÉRAL DE TRAITEMENT DE L'INFORMATION DANS L'ENTREPRISE	Ensemble cohérent d'applications* reliées entre elles. (Voir APPLICATION).

T

T A F	Travail A Façon.
TABLEUR	Programme* spécialisé de création et de manipulation interactive de tableaux visualisés utilisables pour différents suivis. (Ex. : Balance règlements) ou simulations.
TÉLÉTRAITEMENT	Mode d'exploitation d'un ordinateur* qui traite des données* qui lui sont transmises par voie téléphonique, télégraphique, hertzienne.
TÉLÉMATIQUE	Techniques et services association télécommunications et informatique.
TEMPS RÉEL	Voir INTERACTIF et Fiche I.9 – Un robot fonctionne en temps réel pur.
TEMPS PARTAGÉ	Voir TIME-SHARING.*
TERMINAL	Appareil qui permet, à distance, d'avoir accès à une «unité centrale»*.
TEST	– Essai d'un programme* avant sa mise en œuvre opérationnelle. – A l'intérieur d'un programme*, examen d'une information conduisant à une de ces 2 réponses : vrai ou faux.
TIME-SHARING	Partage du temps d'utilisation d'une «unité centrale»* entre plusieurs utilisateurs. (cf. MULTI-PROGRAMMATION).
TRANSISTOR	«Composant électronique»* amplificateur, modulateur, détecteur de courants.
TRAITEMENT	Ensemble des opérations exécutées pour obtenir un résultat (en informatique : calcul, contrôle, stockage, édition...).
TRAITEMENT PAR LOTS	Voir BATCH. *
TRAITEMENT DE TEXTE	Une machine de traitement de texte est un «ordinateur individuel»* doté d'une imprimante qualité courrier et d'un support d'archivage des textes (disquettes* en général). Le logiciel de cet ordinateur est un programme* spécifique spécialisé qui permet de créer un texte, de le modifier, de l'imprimer. Son utilisation pour la création de rapports, textes, lettres, documentations, ou leur correction, conduit à un gain de temps important.

TRANSPAC	Société privée chargée de la télécommunication entre ordinateurs utilisant un réseau spécifique.
TRI	Classement selon certains critères. (Ne pas confondre avec SÉLECTION).*

U

UNITÉ CENTRALE	C'est la partie de l'ordinateur*, pris au sens large, qui contient processeur* et «mémoire centrale»*. (Voir ORDINATEUR et Fiche I.2).
UNITÉ DISQUES ou DISQUETTES	Périphérique* permettant lecture et écriture sur les disques ou disquettes.
UNIX	Système d'exploitation* multi-poste standard.

V

VIDEOTEX	Utilisation des téléphones et des téléviseurs comme terminaux* de télé-informatique. (Ex. Antiope, Télétel).
TELETEX	Communication inter-entreprises utilisant les réseaux* de transmission de données. (Ex. : TRANSPAC) *.
VOLUME	– Quantité d'informations à traiter. (Ex. : Nombre de clients, nombre de factures...). – Volume d'un fichier : longueur d'un enregistrement* multiplié par le nombre d'enregistrements que le fichier sera susceptible de contenir. (Voir LONGUEUR) *.

W

WINCHESTER	Type de «disque dur fixe»*.

X

X - 25	Procédure normalisée de transmission utilisée par TRANSPAC*.

Z

ZONE	Dans un enregistrement, c'est l'emplacement réservé à une information élémentaire. Ex. : code client, raison sociale, adresse : cet enregistrement comporte 3 zones contigües. (Voir ENREGISTREMENT, DESSIN).