THE BASSOON REED

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FOREWORD

I wish to extend a cordial greeting to all members of the IDRS and sincerely congratulate Ms. Amar for her remarkable work in translating this article.

It is a bit unfortunate that by now the ideas expounded in this text have been much further developed and even warrant further specialized publication. (These ideas include the details of historical and mechanical aspects of reedmaking, production of new tools, etc.).

Nonetheless, we are presenting this first draft for discussion, and hope that it will be of interest to you.

J. M. Heinrich
Sept. 1978

Note: Many slides were shown at the conference, but it is impossible for me to reproduce them. I would certainly be willing to repeat the conference anytime.

TRANSLATOR'S NOTE:

This translation was begun at the suggestion of Christopher Weait who felt that it was a shame that the results of Mr. Heinrich's research were not more easily accessible to North American bassoonists. I have remained as faithful as possible to the original.

As Mr. Heinrich mentioned in the foreword, research has continued since the publication of the original article in 1976. I have added "updates" wherever they were necessary. In this way, the reader has been informed of Mr. Henrich's most recent discoveries. As well, Chapter V bis has been omitted at the request of the author.

I would sincerely like to thank Mr. Heinrich, Mr. Weait, and Dr. Benjamin Zifkin, without whose invaluable assistance this project could never have been completed.

Joëlle Amar
Sept. 1978

THE BASSOON REED: AN ANALYSIS OF ITS CONSTRUCTION AESTHETIC MECHANICAL AND BOTANICAL ASPECTS

Introduction

The bassoon reed presents technological and theoretical problems. The physicist Bouasse considered it one of the most challenging problems in classical physics. In this paper, we will give two descriptions of reeds, one acceptable to a physicist and the other a practical description concerning reed scraping.

Aside from scientific problems, the actual construction of reeds demands such flair, intuition and dexterity that the public would, if it knew, never believe it. A violinist obviously makes neither his violin, nor his bow and strings. An oboist or bassoonist, however, is forced to realize his tonal ideal by making a reed personally adjusted to his taste. This reed, though suiting him, will not necessarily play acceptably for his colleague. These are certainly difficult instruments, where sound concept must be controlled by knives and files before one can even begin to play; where a reed lasts maybe three weeks if one is lucky . . .

Let us read, (for the novice's sake) the eloquently clear section on reeds from Laborde's article on the bassoon. One might argue that this dissertation dates back to the eighteenth century, and that surely we must have progressed since then. Alas, this is not so. We don't even know anymore what one did in those days. These days we make gouges and profilers, but the failures are still numerous. We think that this stagnation is due to the gradual loss of the (technique) possessed by Renaissance artists, especially since our modern instruments are based on these.

It takes years of study and a competent teacher for one to acquire a reed-making technique. Early musicians, however, had to learn to make their instruments "speak" quickly and started from scratch. If not, nobody would have bought dulcians or other such instruments if the buyer had to guess how to make them work. Having no models or guidebooks, these pioneers had to formulate rules for reed dimensions (e.g. Laborde). Perhaps we will find them again.

The fundamental problem is still that of cane selection to prevent subsequent failure. This is done empirically – there is no real basis for selection.

There are two basic problems: 1) that of the shape and scrape of a reed, and 2) that of cane selection.

Recently, several works on the bassoon reed have been published. Most deal mainly with reedmaking technique: two are research papers. We must admire these authors for they are working a virtually uninvestigated field with no theoretical base or connecting ideas to guide them.

In view of all this, we are proposing to provide a theoretical lead and direction for research. We will analyse the technology of the reed to see if the proposals we make correspond to our theory or lead us on to others. We will do some applied plant anatomy and a lot of geometry.

Working systematically will present some problems: We will talk of parallel and elliptical gouges, of concave and convex forms, etc. Some might propose that we make sound pictures of each case and the proof would be made: we would know the best solution. This is impossible since there are so many other parameters. [13]We think, however, that we have sufficient knowledge to present a coherent theory to provide the ground work for further research.

II DESCRIPTION AND OVERVIEW – Does a theory exist that allows one to characterize a bassoon reed?

a) Resumé of Construction. Here, briefly, are the steps involved in making a bassoon reed. (2)

We start with tube cane of a suitable diameter. For bassoon, these tubes have a diameter of 24-26 mm. (Plate 1 No. 3) (3)

The tube is split into pieces. (Plate 1, No. 4) This process is called "flèchage". We will discuss this when we deal with the gouge and measurements in reed construction. (4)

The pieces obtained are gouged, i.e. the inner surface is thinned. We obtain a thinner surface of regular profile. (Plate 1, No. 4) (5)

The gouged cane is then shaped. There are two ways to do this. (6) The result is the shape illustrated in dotted lines on the cane. (Plate 1, No. 4) The future vibrating portions – the reed blades – are labelled ABCD = blade no. 1 ABC'D" = blade no. 2.

The gouged and shaped cane is then scraped i.e. profiled. (7) (See Plate 1, No. 4) Between C'D'CD we remove the bark and thin down the blades. We will describe this further later. Note that it is now possible to fold the cane without breaking it.

The gouged, shaped, and profiled cane is folded along AB. (Plate 1, No. 5) Beyond CD and C'D', the cane is scored. We separate the two pieces by cutting them apart. We then superimpose the two halves. We will show that the quality of the reed will be influenced by these processes.

The blades are pressed firmly one against the other to allow one to insert a mandrel. (Plate 1, No. 5) The scored area must be made cylindrical to allow the reed to fit on the bocal. Above all, blades ABCD ABC'D' will become longitudinally and transversely curved, to a degree influenced by the characteristics of the cane, the mandrel, the folding, the shape of the blades, etc.

Finally, one must apply wires and binding and cut the tip if this has not already been done.

These are the basic operations; this being a technical paper, an outline is sufficient for our purposes.

One may ask at which point the subtle differences in method or proportion are critical. How can one orient oneself toward a certain tone colour? By the end of this paper we feel we will have shown how a reed can be condemned since the splitting of the cane and how each step in construction is important.

b) Description of the bassoon reed

Since the last century, there exist 2 systems of bassoon – French or Conservatory system and German or Heckel system. Each school of bassoon playing uses different reeds.

– The Heckel type reed is represented in P11, No. 1

a/ shows a front view (blade ABCD).

b/ shows a side view (blades I and II).

The English consider the blade portion or Bahn (German terminology) to include not ABCD but to begin at the line S.

In b we can see the sudden difference in thickness of the blades at S. This is the most distinctive characteristic of a Heckel

PLANCHE I

G.A.M. N° 82 – 83 – LE BASSON (IIle partie)

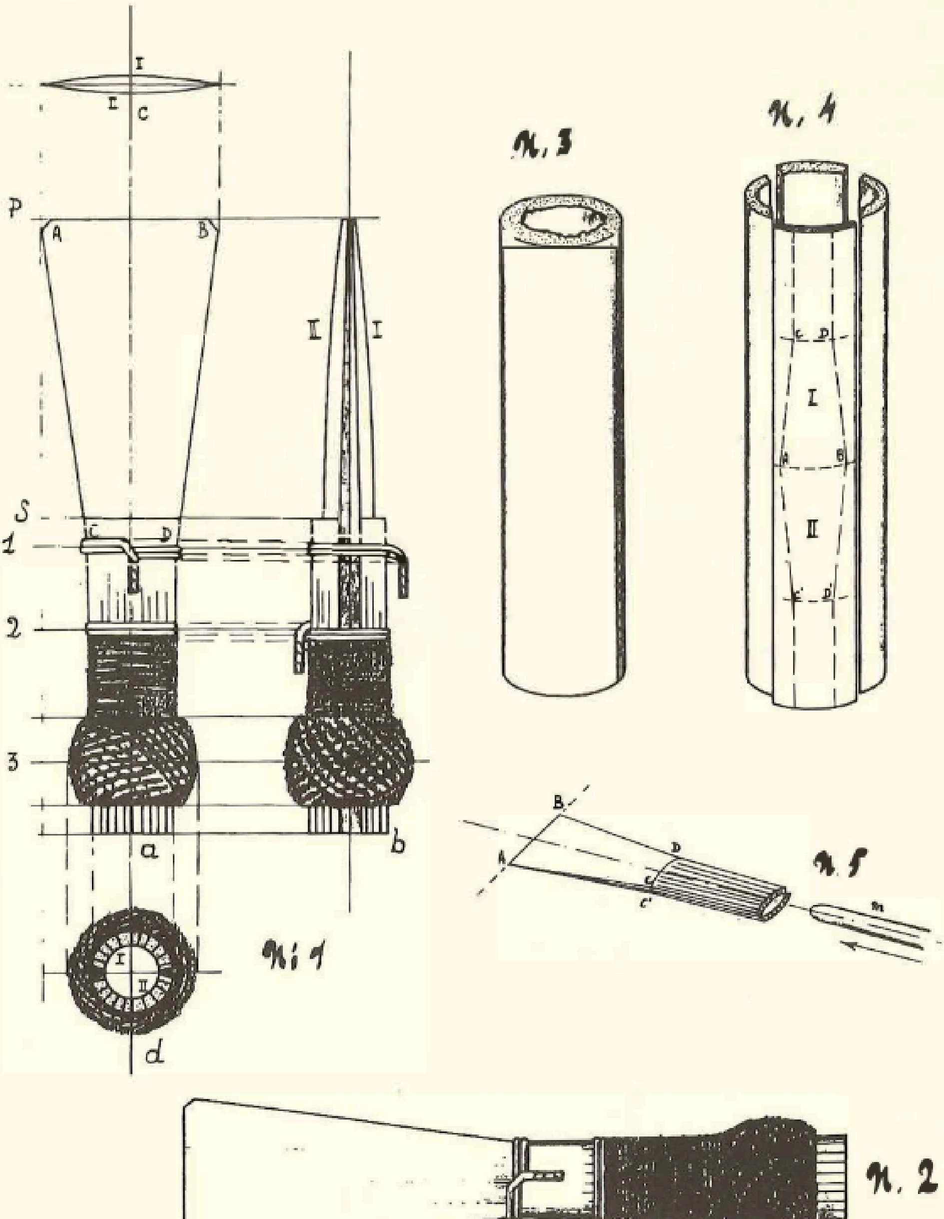
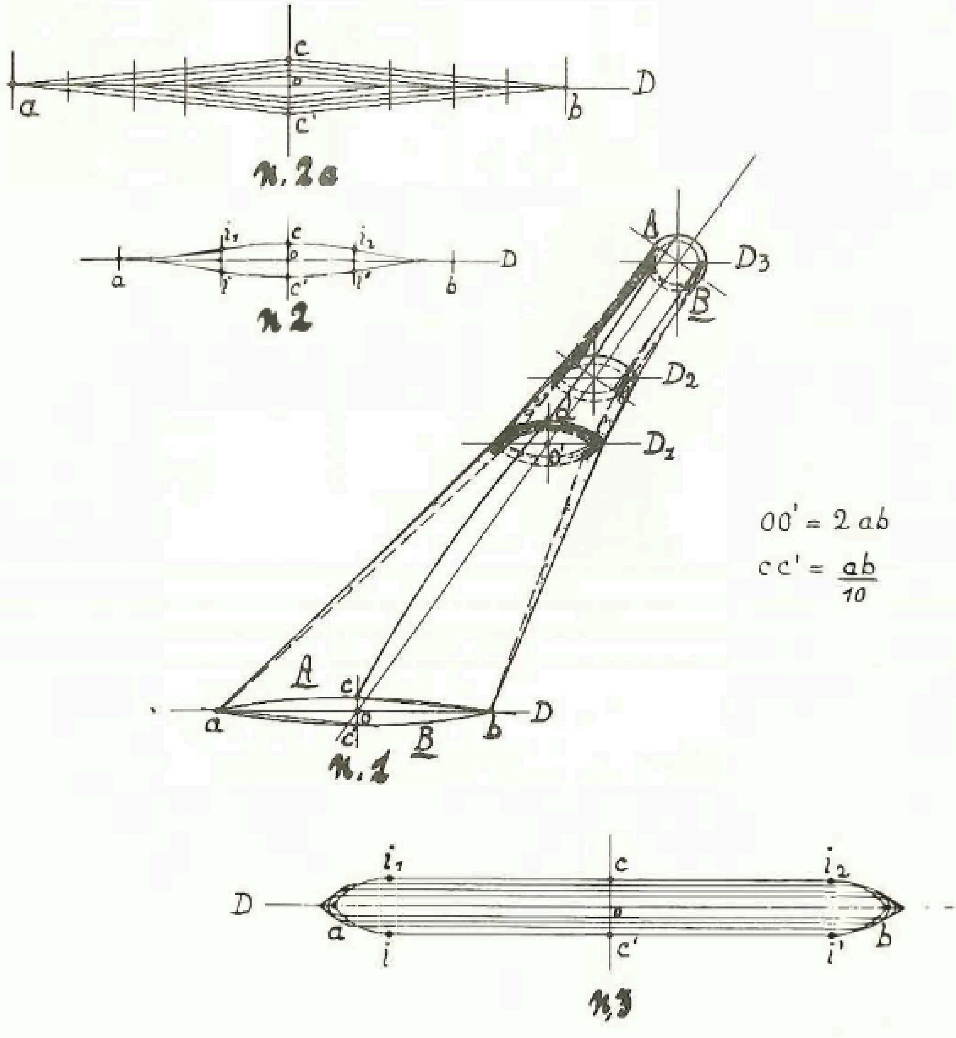


PLANCHE Ibis

G.A.M. N° 82 – 83 – LE BASSON (IIe partie)



reed. The bark of the cane is removed only starting from S the shoulder or Kerbe (German terminology). AB is the tip. In c, we see the tip opening or Offnung borne (GT). The ligature and wrapping include Pl 1, no. 1 a

1st wire-metal wire (vordere Zwinge)
2nd wire (mittlere Zwinge)
3rd wire-butt wire (hintere Zwinge)

From the second wire till past the third wire, the reed is wrapped with thread which is then varnished. This is the wrapping or "Wickel" (GT). The part around the third wire is the Turk's head. (8)

At d we see the butt opening (German – Offnung hinten) of the reed. We see the two pieces I and II and the scoring. Between the first wire and the bottom of the reed is the butt or schaft (GT). Between S and the second wires or between the first and second wires is the throat or Taille (GT).

The Buffet reed Pl. 1, no. 2 is more easily described.

The region corresponding to AB is still called the tip (French – pointe). The region near the first wire is the heel (or talon FT). The differences between the two reeds are that no. 1. There is no shoulder S in the Buffet reed. The thickness of the blade diminishes gradually from the first wire to tip. The result is a heavier, more "temperamental" reed. No. 2 the tube or butt is much longer on a Buffet reed. We will return to these points.

N.B. On Pl. 1, No. 1 and 2 are drawn at twice normal size. These models vary depending on the makers. Numbers 3, 4 and 5 are smaller than life and not drawn to scale.

c) Does a postulate exist that adequately defines a good reed?

Before answering this, we must more thoroughly define the reed. Pl. 1 bis no. 1 gives a schematic theoretical view. In Pl.1 bis no. 1, the two constitutent halves of a reed are exactly superimposed, containing right angles at D, D1, D2 and D3. In practice, the two halves are sometimes laterally offset, but the reed works all the same. Some oboists (and bassoonists) offset the blades voluntarily. The blades are the same basic shape, otherwise we would have lateral inocclusion. The reed is symmetrical with respect to the axis oo' (see Pl. 1, No. 1a).

At D3, the butt opening, the conformation is cylindrical. A bit higher up, is the third wire. At D2, we find the second wire. The conformation of the tube becomes oval. At D1, the first wire position, the oval is further flattened out. The space D1-D2 is variable according to the will of the reed maker.

Between (D1) the heel, D1 and (d) the tip, D we have the two blades. The reed widens from D1 to D1, and the flattening out continues progressively and reaches a maximum at the tip. Topographically speaking, point c is "lower" than point d. This goes without saying. The blades are slanted and run concurrently towards the tip (oc o'd).

These days, oo' = 2Ab – the length of the blade is equal to twice its width at the tip. This is not, however, the case for either oboe or contrabassoon reeds. When this drawing was made, this rule and other related ones (to be discussed) had not yet been found. We will show that reed makers of the Baroque era used simple geometric procedures to determine tip width, back width, and blade length. We notice that the narrower the reed, the longer it has to be to sound well, and vice versa for a wide reed. (Update: 9/78. A separate article dealing with this topic has now been completed.)

We began working on this theory by checking the previous literature. Different authors supplied figures (with no preconceived theory) that indicated that the average tip opening is equal to 1/10 the width of the tip (cc' = 1/10 ab). An example in C. Weait's work: tip width = 15 mm. tip opening 1.5 mm. This is not inalterable, however. M. Boet has stated that certain bassoonists play "closed" on reeds with thick blades and others play "open" on reeds with very thin tips.

A very important line is the one which links (parallel to oo'), the point c to point d along the blade surface. We can call this the "crest" line. Cutting the reed in two along cc' or (od') and measuring the thickness along this line gives us the spine.

The thickness and elevation of the spine diminish from d to c. Laterally from the spine towards the sides, this is also the case. Though the thicknesses are determined by the reed maker, the curves created are not. The cane will react as it wants to to tools; its structure will determine the geometry of the curve.

Hans Lotsch, a bassoonist from Munich, recently published a work on reed construction (without profiler). He mentions the spine but further describes it as the

"Mittelsenkrechte" – translated word for word as perpendicular median – i.e. the axis of the reed. He also speaks of the sides (Seitenflache) as lateral surfaces.

We ask now if a good reed has constant characteristics. We know that good reeds can be long, short, narrow, wide, etc. We will describe parameters that determine a reed's quality.

– dynamic range. i.e. hard or weak reeds. Hard ones make the pp range hard to attain. Soft ones collapse at attempts at ff nuances.

– pitch. One speaks of "sharp" or "flat" reeds. Sharp ones make certain notes rise unreasonably out of proportion to the others. With flat reeds, one has trouble raising certain notes to pitch.

– tone colour. There are smooth dark reeds and bright reeds in each of the above categories. Statically, we often have reeds which are too bright or too dark but we rarely obtain the satisfactory compromise that makes a good reed. J. Kergomard will enlighten us on the acoustical aspects of these reeds.

If the problems of pitch and resistance are mastered, tone is still a major problem. Musically this is of primary importance. We will emphasize this aspect in the rest of this paper. A good reed is one which produces the desired sonority.

We feel that it is possible to recognize a good reed without playing it. The criterion is the shape of the tip opening before and after pressure is exerted on the blades. There is a conformation for a bright reed and one for a dark reed. Our theory will be the guideline to our research.

The geometry of the tip opening is due to several parameters: the quality and peculiarities of the cane itself, the shape of the blades and the effects of the operations performed by the reed maker. We have already described cane anatomy in a previous publication. We will add a few details but our goal is to show the effects, good and bad, of the techniques used by the reed maker. No multidisciplinary study of reeds exists.

If we study an excellent reed, we know that the reason for success lies in the geometry of the tip opening. We can learn how to obtain this geometry by going back to basics: to characteristics of the cane itself and to the steps followed in construction.

This should allow one to recreate the conditions that produced the good reed. A reed or piece of cane is not good because of one factor, but because of a favourable compromise between several parameters.

Here is our basic postulate:

1) *The mellow reed*: Consider Figure 2, P1. 1 bis. We have stated that dark reeds almost always have a tip opening contour containing *"points of inflection"*. Line acb, for example, is divided by points of inflection il and 12 in the central portion of the *convex* il c il_2 followed by arcs ila and ilb along which the profile is *concave*.

In ideal cases, these points occur symmetrically with respect to coc' or better still, to o.

If the shape of the reed and blades at rest permits, a more important phenomenon occurs. By taking the blades between thumb and index finger and gradually applying pressure at the point where one would normally hold the reed with one's lips, one notes that the closing of the opening begins at the edges a and b and continues symmetrically towards centre o.

This calls to mind the mathematical phenomenon of the "degenerate curve". The surface contained within the arcs ac'b and acb keeps the same shape as it diminishes in size. It finally degenerates and merges into o. The closing begins at the sides and goes towards the centre.

This phenomenon must be symmetrical and bilateral, otherwise the tone quality is affected. We will discuss this further shortly. (Update 9/78. We have found variants – the speed of this phenomenon is very important.)

2) *The bright reed*: At rest, the shape of this opening is very different. It is more flattened. It follows that the distance between the blades at a and b is larger than in Figure 2, P1.1 bis.

Pressure causes the reed to close but not the same way. See Fig. 3, P1.1 bis. The blades flatten out, and the initial curve disappears. Points ii' il i2 are not points of inflection but are simply connecting lines. They join, for example, ci2 to arc i2b. (Certain reeds already have this geometry). Remaining flat, the two blades are parallel until point D where they eventually meet. a and b are displaced sideways.

To summarize, for a dark reed, the tip closes from the sides to the centre while for a bright reed, the blades flatten out, become parallel, then meet. *Comments:* There are many in between cases and the problem has barely been touched. The described phenomena seem incontestable. Only one author partially described our theories – H. Lotsch, quoted earlier. Twice in his work we read that a good reed must close from sides to centre. This bassoonist plays a Heckel system bassoon and has a smooth dark sound. We feel that this is a further affirmation of our postulates. Despite a listing of inferior tip openings, Lotsch does not state our postulate. However, the use of the tip opening as a guide for scraping is a subtlety not previously published.

Observation of this phenomenon is difficult for the inexperienced observer. Even some worthy bassoonists we contacted found it difficult to grasp. The observation must be made in true to life conditions, i.e., with a wet reed.

The cause of very wide reeds (17 mm.+) bothered us a bit. (Update 9/78. This problem has now been solved in continued research). In a batch of such reeds, most of which act like the bright ones we discussed, certain still have a darker, smoother sound than others. Perhaps 1) the back of the reed dampens the vibrations the more the reed closes, or else 2) one must know what goes on in the mouth as one plays. Early authors recommend that one should incline the reed in the mouth to smooth out the sound. It is difficult to simulate this with the fingers for our research. If the reed is inclined, the lips press down the sides of the blades and facilitate the "dark" opening. FRÖLICH says "If the reed is too wide we can't control the air."

We could even say that P1.1 bis 2 resembles the human lips. A physicist might try to explain this phenomenon. Our role is to increase our reed success rate using the technology we have at hand. We will remark only that for a dark reed, the closing is progressive. For a bright reed the closing is abrupt and there is a shock to the blades which might be transmitted through the crook. This could also be linked to the variation in the surface at the tip of the reed and its repercussions on the maintenance of vibrations through the tube.

In Summary, we consider the bassoon reed to be a mechanical system formed by the juxtaposition of two pieces of cane. It functions as a valve. We know what the conformation of this valve must be to obtain the desired sonority. We must know how to adjust it.

III Review of Cane Anatomy

We won't review basic cane anatomy here. This has been dealt with in GAM 71 and a seminar on this subject was given in Brussels. Let's remember only that cane has no structural similarity to woods used in instrument making, or even to shrubbery.

In the introduction, we announced that we would do some applied vegetable anatomy. We must consider the cross-section mechanically and geometrically. The description given previously is of a whole formed by a layer of parenchyme with tubes running through and then a layer of sclerenchyme. We could call this a bilateral structure, but we are dealing with a much more complicated structure.

Briefly, we concluded that there are three variations in the fibrous structure. 1) Transversal or radial variations. The fibers are further apart as one goes towards the inside of the tube. ( ) This variation is the easiest to observe, but unfortunately it does not vary consistently. This adversely affects reed making. 2) The longitudinal or axial variation. This is from top to bottom of the tube. The study of this variation has not been completed. The overall concept is that the tube is more solid at the bottom than at the top because of the (relachement) of the parenchyma, but one must carefully consider the compensations for this made by the sclerenchyma. We must be careful when mentioning a diminution of strength towards the top. We must know which strength we are talking about and which resistance to what type of effort. Here is a biomechanical example: Consider a spine formed of a few long vertebrae with few joints and another made of many short ones with many joints. Which one cracks easier? Similarly, in cane, the parenchymal cells, regularly stacked, are shorter at the bottom and longer on top. In the bassoon reed, this fact has an indisputable effect. We will discuss this with respect to assembly.

3) The circular variation. This is linked to anatomic laws. (Left or right oriented cane) and to the disposition of the bundles. This variation causes problems during reed scraping. A special machine was constructed to study this.

In general, the problem resembles that of reinforced concrete used in construction. The parenchyma is analogous to the concrete, and the sclerenchyma is analogous to the metal reinforcement. Here are some additional comments.

1) *The chemical point of view.* We have not yet mentioned the problem of the composition of the cell walls. (number of layers, crystalline structure of cellulose etc.) This study demands equipment unavailable to individuals.

We propose therefore to study cane and reeds as simply as possible. We think that a knowledge of the macrostructure will help more than a knowledge of the microstructure. Study of the latter could be done one day to perfect this research and satisfy curiosity. We will mention this later with reference to cane selection.

As for chemical composition which influences mechanical properties, we obtain an overview very simply. Vegetable cells essentially contain: 1) pectic matter (intercellular cement) 2) cellulose (crystalline structure) in chains of variable length 3) hemicellulose i.e. lignins (amorphous) in the cell walls reinforcing them.

For more detail, we refer the reader to specialized works.

What interests us most is the distribution of these substances on the tube cane surface at different levels from bottom to top of the internodes i.e. Does cane have the same degree of lignification of the cell walls everywhere? In a study of pigmentation mechanisms in cell walls Dr. Hanno Richter of Vienna distinguishes three principal types of component distribution in the plants studied:

- homogeneous (same throughout)
- gradient (concentration of a given substance varies in a given direction)
- mosaic (self-explanatory).

Dr. Richter uses florescence and reagents diluted to safe levels. Besides the preparation of one or two reagents, the making of cane cross sections involves procedures of High School levels difficulty! Going as far as Dr. Richter would be of no practical use to us since with a very fast and simple technique we can find out the distribution of the lignins on the whole piece at a macroscopic level. We wonder if the cane would be of the same resistance throughout:

We will discuss our technique with reference to cane selection. We have found that for cane, the lignin distribution is in mosaic and in concentric rings.

The effect of these rings can be great especially in construction of heavy clarinet reeds. The vibrating portion is in the deeper layers of the reed and at this level, the lignification is heavy while in the middle, it is less. We have rings which increase in lignification.

Inside these rings, the "mosaic" aspect can be quite accentuated. This has always given bassoon reeds with blades that crack easily.

To complete and complicate this . . . There's also an imbrication that we will explain in the next paragraph. Unfortunately, the same reagent doesn't show all these features.

2) The difference between internodes of right or left orientation is caused by a group of bundles we mentioned in our exposition. This phenomenon is sometimes obvious, and at others difficult to observe.

This group is an extremity of the primary leaf trace. We use this term for the bundles from the leaf which penetrate the stalk. The anatomy of the leaf is therefore present in the stalk.

(Practically, this means that if at the base of the internode the quality is quite homogeneous, this is not found to be the case in ascending. The half containing the beginning traces of the leaf always seems more lignified than the other half.)

Consider for example, Pl. II No. 1. AoC divides the section in two halves ABC and ADC. The bulkier side, depending on the orientation will be either found between Aa or Ad. The side where it is found usually reacts more strongly in tests for lignins. However, we have also seen a case where this was exactly the opposite, proving that one must be careful when working with biological material.

Note that with composite lignin-cellulose reactions, one obtains, on the side opposite the bulky one, dye colours indicating the presence of more cellulose.

3) With respect to parenchyma, the cross-section of a dry untreated tube shows two extremes.

1—The parenchyma or basal tissue is white and the fascicles are easily distinguished by their dark covering. Overall the effect is "marbled". Seen through a microscope, the parenchymal cell walls are thick and white.

2—The parenchyma is organge-yellow as is the covering of the fascicles. Overall, the sections seems unformly coloured. Microscopy shows the parenchymal cell walls to be thin and coloured.

We cannot statistically confirm this yet, but the "white" case seems to be related to a large leaf trace, while the "coloured" case seems to be related to a smaller one. It must be mentioned, too, that experienced specialists tell cane quality by the anatomy of the leaves.

4) Some suggestions about the sclerenchyma: The variable thickness of the outer sheath following the epidermis is itself variable among different specimens of cane. It ranges between 0.2 and 0.4 mm. The anatomy of the sheath is also variable. The differences range from:

1—a compact continuous ring of fibres, the sclerenchymal ring being of approximately the same width throughout.

2—a succession of little sclerenchymal bundles giving the sheath a discontinuous appearance.

The practical effect of anatomical differences can only be studied in conjunction with other parameters. This is the goal of our special selection microscope. It is certain, however, that a reed with too little sclerenchymal sheath will give reeds that play too flat. Differences in the fibre are found: 1) in the colour of an untreated transversal section, and 2) in the thickness and constitution of the cell walls and the size of the lumen (internal hollow). (12)

In 1942, G. Jayme and M. Harders-Steinhauser studied the length of sclerenchymal fibres of different origins. They found appreciable differences linked to the place of origin of the plant. (13) We have not yet researched this, but we will cite the figures given for Italian Arundo Donax (called Canna gentile in Italy). The length of the fibres varies between 0.1 mm. and 5 mm., the width between 0.006 mm. and 0.025 mm.

We stated that the sclerenchymal sheath lignins are not hygroscopic and do not react chemically in the same way as the lignins of the fascicle coverings.

We can conclude this section by saying that in future, we must find a link between the geometry and the chemistry of the cellular web.

Referring back to our example of reinforced concrete — one must know the quality of the concrete as well as the quality of the metal reinforcements before one can study the geometry of the placement of the reinforcements.

IV The Gouge

Gouging is the process by which one evens out and thins down the pieces of cane obtained by splitting the tube cane. These pieces are worked on the inside only, the bark remaining intact. This process is called "das Innenhobeln" in German, i.e. planing of the interior. (Scraping takes place from the outside).

The tools used are not always gougers in the true sense. The desired profiles and thicknesses may or may not be constant throughout the length of the piece. (See *Ludwig* gouge)

Here are several comments on the gouge:

a) Splitting. At present, there is only a geometrically illogical guideline. Consider P1.II No. 1 which represents the cross-section of a tube of cane. A represents the point of insertion of a branch (two-year old cane). The two central generators pass through A and C. The diameter AC is the axis of symmetry of the cross-section. Several authors split the cane into the pieces AB, BC, CD, DA. However, it would be more logical to split along the dotted lines, i.e. along ab, bc, cd, da. The reason for this is given by the morphology of the tube. Its cross-section is often irregular. Looking more closely, we find that the form is that of four arcs of a circle. cb and da are small and give narrower pieces of cane, and ab and dc are large and give wider pieces. The cross-section is more often oval or elliptical. AC is the bigger axis and DB the smaller. The diameter of tubes used for bassoon reeds is between 24 and 26 mm.

We have shown photographs of cross-sections containing arcs larger than 28 mm., and, in the same cross-section, an arc of less than 24 mm. However, the total diameter is still 24 to 26 mm.

The usual manner of splitting gives asymmetric pieces since they contain a portion of the large arc and a portion of the small. These differences affect the future of the reed. We are presently studying the implications of this.

We have only mentioned the shape of the tube, not its internal structure. Our preoccupation is to replace splitting by a simple machine showing the cane structure so one can avoid using a piece that is condemned in advance. This machine is described in Ch. 8 and uses all our knowledge of the technology of the reed.

b) We saw cane being gouged in the Var. The pieces passed through the machine very efficiently. Some bassoonists advise that cane be soaked first. One even advised 24 hours! Most people soak it for a few hours.

c) H. Lotsch mentioned that one can select cane by the way it reacts to the tools used. He says that certain pieces of cane resist being gouged but then they settle. One should remember what we said with respect to the distribution of the lignins. The deepest layers seem very lignified, but are followed by a softer layer after which the lignification again increases. This question is not yet resolved.

2) *The Manual Gouge*

This is the old process still used by ancient instrument specialists today. J. LeGuy states that one does it accurately after a while and that one becomes free to experiment with different profiles. Ozi's bassoon method, dated before the French Revolution, describes the technique. (Update 9/78) [Historically, more important details have been discovered. Details will be printed in another article.] One important note: To eliminate the irregularities due to the gouge, one worked with a round file. We will soon treat the geometric problem of the gouge.

3) *The Mechanical Gouge*

Today, even purists admit that manual gouging is a waste of time and that a machine does it better. Gouging machines appeared soon after the appearance of woodworking machines, in the second half of the last century.

Before talking about gougers or profilers, we must mention that these are very small machines, not even the size of a shoebox. They are moderately heavy and very easy to work with. They are virtually unknown in France, as is the rest of the reed making machinery. (15) In Germany, however, in each city there is at least one bassoonist who owns all the machinery and makes his own reeds. The result is that American and German bassoonists have attained a very high level of reed success.

We bought some machines and studied their characteristics. We will not treat rotary machines which wear away rather than gouge the cane. A few of these exist, i.e. Christlieb in the United States.

a) Description of a gouging machine.

One must obtain a profile resembling the one in PL.II No. 2. P1.II No. 5 shows a gouging machine seen from the side. On a block S, clamped to a table, is found the mould M in which is placed the cane. The blade C, like a plane blade is shown without the shaft for clarity. It is held by F, a regulator fixed to the bar B which has a handle P. B pivots about an axis. By holding P the handle, one pushes the blade and planes until the desired thickness is obtained. Thanks to A, the adjustable knife guide, the blade cannot go any lower and the operation is completed. This description is very brief. Practice is necessary for successful gouging. P1.II No. 4 shows the assembly from the side. The cane R rests in the mould M. The blade C is fastened to the shaft F. The thickness e of the shavings is regulated by careful adjustment.

While the central part of the knife works in loosely packed layers, the edges work in denser cane. With the cutting angle being a function of the consistency of the cane (see anatomy section – three variations), one cannot have it as accurate as one would want since it should vary throughout. The only way out is an adequate shaving thickness. The luman 1, or distance separating the edge of the knife from the edge of the shaft is variable. At the centre of the cane, 1 is small and the edge of the shaft acts as (presseur), preventing splitting. On the other hand, near the edges, 1 is bigger (L) and the edges of the shaft do not function as (presseur) any more. There is no (contre fer) as in an ordinary plane. On the machines of some of the larger reed making firms, the alternating motion of the plane is obtained by a crank, thus speeding up the process. For the individual, the hand-operated gouger helps a lot.

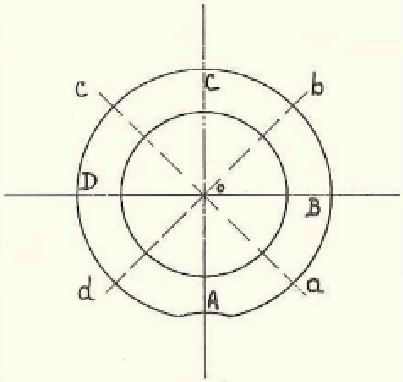
b) The Knife. Consider P1.II, No. 3, Fig. d. which represents the knife of the profiler, which moves from right to left, with angle alpha remaining constant. This tool planes in the direction of the fibres. In woodwork, this is called working along the grain. Cane is the only monocotyledon used in any kind of woodwork.

We will briefly cite the characteristic angles used in the cutting tools. Angle c) The cutting angle. This varies between 15° and 25° for hand-operated machines. The smaller angles facilitate cutting into the wood. This angle is a function of the wood to be worked and the quality of the cutting

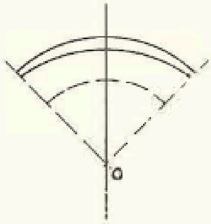
PLANCHE II

G.A.M. N° 82 – 83 – LE BASSON (IIIe partie)

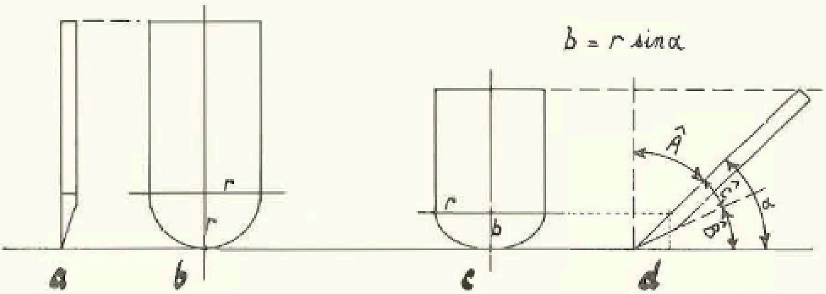
"gouge" – généralités



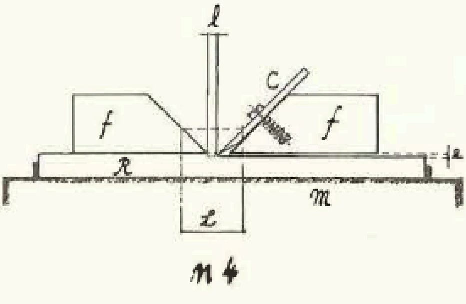
n. 1



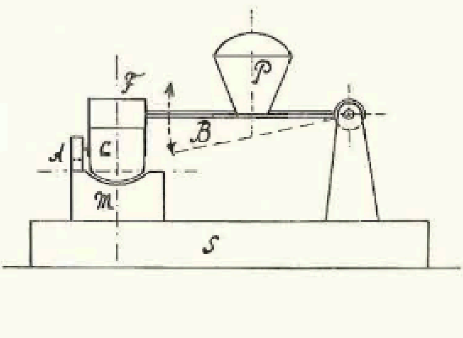
n. 2



n 3



n 4



n. 5

PLANCHE III

G.A.M. N° 82 – 83 – LE BASSON (IIIe partie)

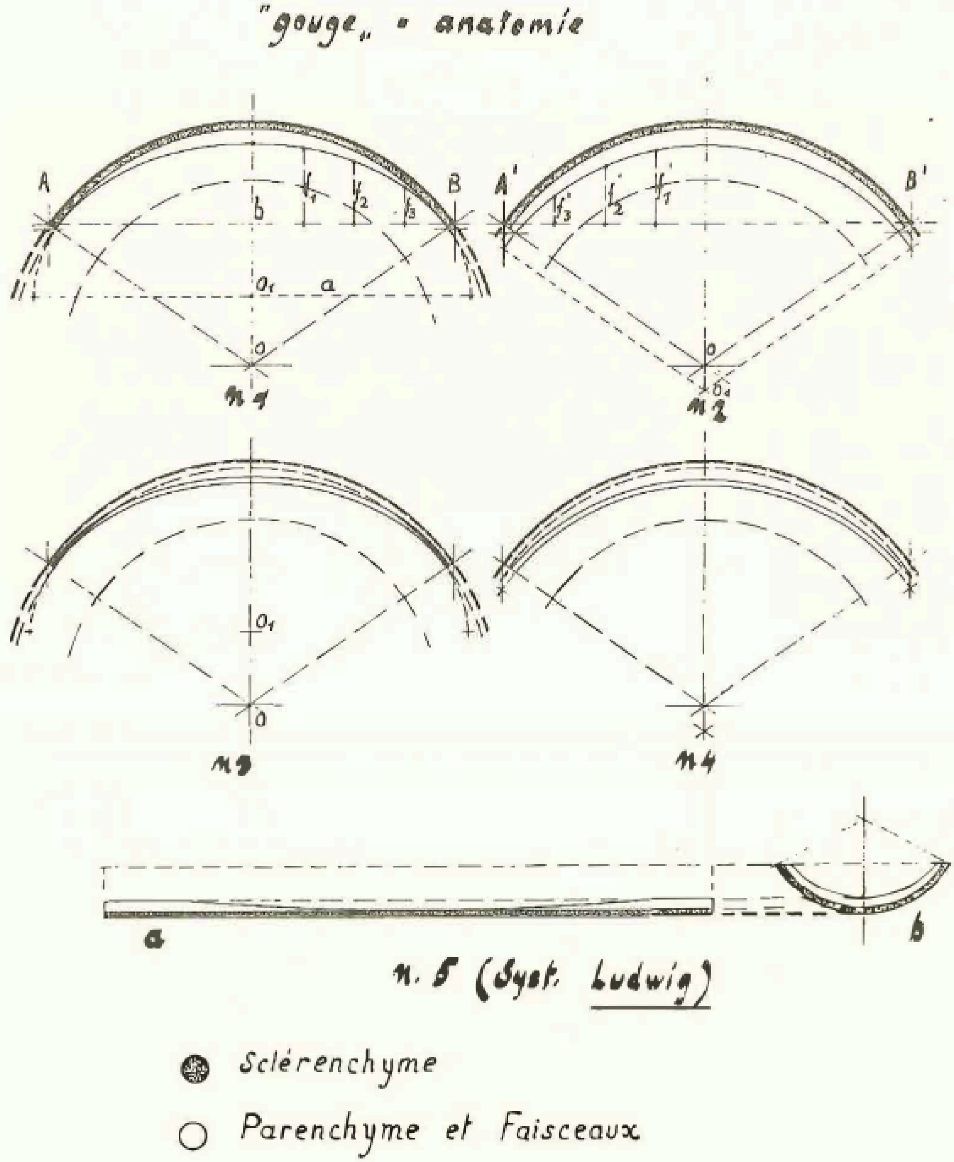
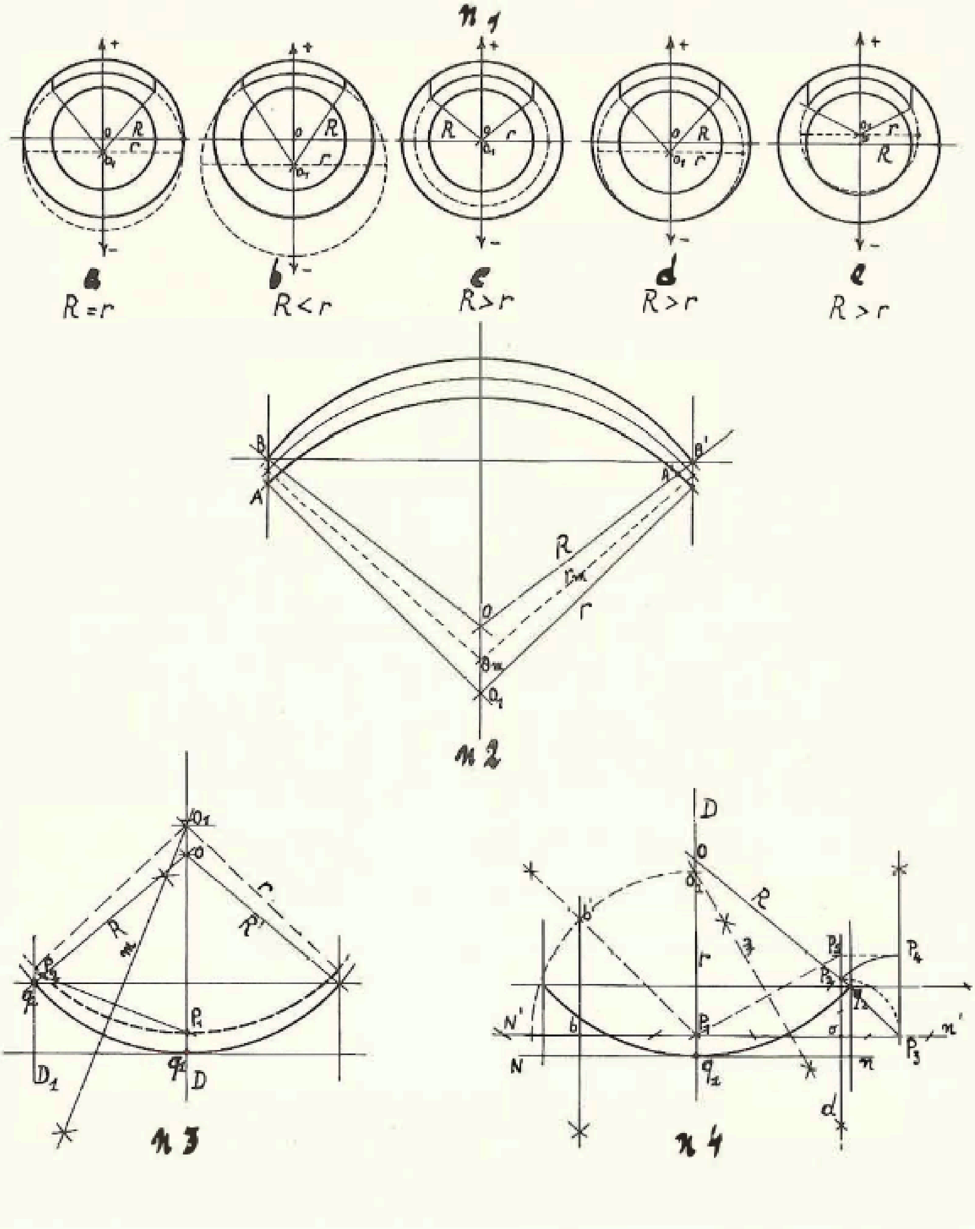


PLANCHE IV

G.A.M. N° 82 – 83 – LE BASSON (IIe partie)

"gouge" - géométrie



edge. Angle B is the angle of (depouille), which prevents (talonnage) of the tool. Angle A is the angle of the preliminary scraping. The larger this is, the easier the rest of the profiling. The sum of angle B and angle C is the cutting angle. This is worthy of our attention for geometrical reasons.

Before proceeding, we must say that any self-respecting craftsman will profile well. Some attach great importance to this and deem a good profile to be essential to the success of a reed. The effect of profiling on cane at the cellular level has been studied by Kisser. He says that in case of torn cane, (something a good knife should not do), the lignified materials give cellulose reactions. We realized that this phenomenon might confuse our study if samples are badly cut. Kisser mentions an "unmasking" of the cellulose, the sheath of lignins having been removed by rough treatment. In this case, the wood becomes very hygroscopic. One should carefully avoid coarse files and sandpaper that could make reeds too soft and hygroscopic. (See remarks concerning profilers.) We must mention however that hand gougers have no shaft and planes do, so the force exerted on the fibres is different.

c) The Effect of the Cutting Angle or the Elliptical Gouge. The machine used in our workshop uses a circular knife. In P1.II, No. 3, figures a and b, we see it face on and from the side. During the gouging, the knife is inclined to 45° (cutting angle) on the cane. The projection of the circular form of the knife will give an ellipse, not a circle. It is well-known in geometry that if one projects a circle on a plane which is not parallel to it, an ellipse is generated. Here, we obtain an ellipse whose large axis remains r but those small aix value is expressed by $b = r \sin d$. It follows that the profile of the gouged cane is an ellipse. This is also true for the manual gouger. Even if the tool is not circular, one can determine the profile obtained with a given angle, by reducing the coordinates.

d) The Circular Gouge. We call this the Rieger system out of respect for its creator. For a long time, we believed that the elliptical gouge was the only one possible. Confronted with the problem of restoring Renaissance reeds, we studied this with the purpose of making a machine. Armed with our research documents, J. LeGuy and I set out to see G. Rieger, a German reed maker near Baden-Baden.

He was astonished by our drawings, all made in vain, since his machines simply gouge circularly! Since then, we have returned several times and watched this expert craftsman at work. The shaft of his plane is a cross-section of a circle. The knife is positioned. One places it slightly behind the shaft. The edges stick out the most. We have here the intersection of a circle, the shaft with an ellipse, the inclined circular knife. With a special grinding stone, all that projects past the edge is removed so that we are left with a knife that corresponds to the circular shaft. The knife is then taken apart and honed, than permanently installed. If we wanted to make a similar knife, it would be like trying to teach a beginner bassoonist to play the Jolivet Concerto!

e) *An anatomical comparison of these two Methods.*

Consider P1.III. In No. 1 and No. 3 is shown the elliptical gouge. In No. 2 and No. 4 we see the cross-section obtained by the circular gouge. The thickness is the same in the middle but the sides vary. The nature of the tissues found at the edges is different. In No. 1 (ellipse), the edges consist of sclerenchyma, parenchyma, and fascicles. In No. 2 (circle), the edges are thicker. No. 3 (ellipse) represents the anatomy at the tip after scraping: the edges are made of sclerenchyma while the parenchyma is seen at the limits of the tip. This region can cause tension which leads to cracking. In No. 4 (circle), the tip is made exclusively of parenchyma and fascicles loosely-packed, but one must be aware of the lignification and rings. In No. 1, there is not much to scrape since the edges are thin. We can eliminate the sclerenchyma to uncover the looser layers. In considering No. 3 and No. 4, one asks which would close easier from sides to centre (our theory). We opt for No. 4 (circle).

A mechanical problem arises: Consider rays f1, f2, f3 in No. 1 and f'1, f'2, f'3 in No. 2 f1 and f'1 are similar, but f'2 is smaller than f3. We can say that for No. 1 (ellipse), the sides are more arched than in No. 2 (circle). Under pressure, the sides of No. 1 and No. 3 (ellipses) flatten out less easily than No. 2 and No. 4 (circles).

We modified our machine to get a circular gouge and found that in spite of the lack of statistical proof and in spite of the interference of other parameters, reeds made from circularly gouged cane are consistently darker and smoother.

We also modified our profiler. We must warn purchasers of these machines that makers of this equipment conceive that the profiler and gouger should be complementary. Therefore there are risks involved in using machines by different makers together.

Ozi states that one finishes the gouging with a round file. Frolich mentions this file too, saying that it has a diameter equal to that of the cane. (See P1.IV, No. 1c) Note that with such a thin gouge (0.6 mm.), one cannot angle the blade without excessively thinning the sides. Almenrader gives no details on profiling, but insists on symmetry. He advises gouging at night since candle-light helps bring out the shadows in asymmetrically-gouged cane.

f) Other Methods. Certain makers use a gouger whose profiler is a composite curve. Using the Rieger system, one is sure of getting the same profile after resharpening (reaffutage) of the knife. Other systems are not as accurate.

The Ludwig system (18) is a mechanical variant of Ozi's method. After gouging, before folding, one thins the cane from the inside near the tip. (P1.VI, No. 5 and 6) Today, we thin from the outside. The Ludwig gouger's knife does not simply gouge. At the region corresponding to the future tip, the knife cuts even deeper. (P1.III, No. 5) The tip is thus composed of sclerenchyma but immediately adjoining this is a very compact layer of fibres. (Mr. Rieger gave use some of the original cane gouged this way, but we have not yet tried it.)

4) Geometric problems encountered during gouging: The particular demands of bassoonists or the need to reconstruct ancient reeds may pose problems that can be easily solved with a ruler and compass. For example, a bassoonist would like a gouger giving an elliptical profile with a specified thickness at the centre and another thickness at the edge 8 mm. from the centre (thus the cane is 16 mm. wide). Similarly, by hand gouging, with a specified cutting angle, what gouge must one use to obtain a given profile? Here is a resume of possibilities.

a) We must first clarify the method of measuring the thickness. Measuring a plank or even the wall of a tube is not difficult, but measuring the thickness of a piece of cane is more delicate. The cross-section is nearly always formed of two differently curved arcs.

Consider P1.IV, Fig. 2. We have arc BB' which is the exterior surface of the cane. We used an arc of a circle with centre O. The arc AA' is obtained by the gouge. This is an arc of a circle with centre O and ray r.

How do we orient the two arcs of the measuring instrument? Between which points should one determine the thickness? In theory, between arcs BB' and AA', one finds the neutral fibre. At one point on this new curve, the arms should be perpendicular to the tangent.

On our drawing, the solution is easy because we are dealing with a bundle of circles and the neutral fibre is represented by the arc of a circle with centre O and ray m. We have $O_1O_m=O_mO$. The measuring arms must always be aligned on one of the rays of the circle with centre O_m (19). In practice, and even in our graphic constructions, this is useless since one cannot find the (neutral) fibre before having found the gouge.

We decided to align the arms on a ray of cane. The error is minimal in theory and insignificant in practice. On the drawing, the arms are aligned on R and one measures the distance $A'B'$.

b) Determination of a circular profile. Consider P1.IV, No. 3. The centre thickness given is P_1q_1 along with that of the edge and the width of the cane. The thickness at the edges is not measured on D', the right angle, but on a ray R. We obtain the desired P_2q_2. We want the ray of a circle along which the machine must gouge. The solution is simple. Join P_1P_2 to obtain a chord of the desired circle.

We construct the median of this chord (m) which cuts the right angle D at O_1 which is the centre of this circle. O_1P_1 *is the ray.*

In P1.IV, No. 1, we show the possible variants. The "centre" of the tube of a cane corresponds to (O,O) on a Cartesian graph. At a, the ray of the cane and the ray of the gouge are equal, but the centre of the curve of the gouge O_1 is found in a negative region. One obtains a profile where the edges are thinner than the centre. At b, the ray of the gouge is larger than the ray of the cane. O_1 is in the negative region. We obtain a gouge where the middle is the same thickness as the previous case, but the sides are even thinner.

At c, the rays are equal as well as their centres. The gouge here has the same thickness throughout. Certain bassoonists use this gouge.

At *d*, the ray of the gouge is less than the ray of the cane. O_1 is in the negative region. With the same thickness at the centre, we obtain a gouge which has sides only slightly thinner than the centre.

At *e*, the ray of the gouge is less than that of the cane, but O_1 is positive. The sides are then thicker than the centre.

Here we mention a few facts about ellipses.

c) Reconstructing an ellipse knowing only the peak of the small axis, one point and the relationship between the axes (20). We thought this was theoretically insoluble, but in practice here is the procedure: One knows the centre and side thicknesses and width desired. One gives the cutting angle of a circular knife of unknown ray which must gouge elliptically. We need to know the ray of the knife. We searched in vain for an analogous problem in geometry books. We found a solution by experimenting with different cutting angles with a sharpened knife (21). See P1.IV, No. 4.

Here is a piece of cane (thick line) with ray R and centre O. The centre thickness is P_1Q_1. The side thickness P_2Q_2 is connected to R. P_2 will then be found on a perpendicular d, parallel to D, but closer to the centre.

With the given values plus the chord P_1P_2, we cannot determine anything. We know the cutting angle, however, and can adjust the knife at a right angle to $N'n$. P_2 becomes P_5 – a chord of a circle. The median of this chord cuts D at P_1. O_1P_1 is simply the ray of the knife.

P_2P_3 represents a side view of the knife inclined at 45° (chosen angle). P_3P_4 shows it perpendicular to $N'n$. Using P_3 as centre, we rotated the knife 45°, turning P_2 to P_4. *Seen straight on using the given values,* P_4 *corresponds to* P_5. This was our method of determining the circle.

Knowing what the circle is, one can reconstruct it. P_1b' shows its profile, $b'b$ is the small axis of the ellipse, and O_1P_1 (P_1b') is the big axis.

The elliptical gouge raises other problems we will not deal with here. These geometric elements may seem difficult, but they can prevent years of experimentation. One could proceed using calculations and analytical knowhow, but the author prefers (and enjoys!) working with a ruler and a compass, as others must have done years ago.

We have just found (22) that the type of gouge used gives the cane specific mechanical properties caused not only by the geometry of the gouge, but also by the anatomy of the cane left in place. These properties will be very important with respect to future operations such as folding, assembly, and insertion of the mandrel.

CHAPTER V – The Shape and its Realization

1) Description and classification of shapes used. By shape of the blades, we mean the surface delineated by:

- the tip width
- the back width
- the blade length
- the nature of the blade contour – more on this later.

Even today, there exists no set classification of shapes. One speaks of long, wide, narrow, or flared reeds. We agree that a wide reed facilitates the low register and a narrow one the upper register. However, to speak in these terms implies that one has a standard. Frölich speaks in terms of tone: If the reed is too wide, the tone is wild, and if the reed is too narrow it is bad. One would probably choose a wider reed. Note that in P1.IV, No. 1, we consider the shape as that of the cut up tube *abcd*. It possesses the ray of the natural curve of the cane. While a reed is being assembled, this shape will undergo deformation. P1.V, No. 4 shows a projection of the quadrisected tube. It is in a plane *P* which is parallel to the longitudinal axis of the cane (i.e. P1.V, No. 1). This plane *P* is perpendicular to *P'* which is the axis of symmetry of the tube.

P1.V, No. 4 shows a classical procedure used in geometry. We see the reed from above and face on. The centre disc represents a cross-section of the tube. Using the right angles passing through O, O_1, O_2, *and* O_3 as orientation lines, we have shown the four basic reed shapes. (The arrows show where the tube fits together.)

In this chapter, we only deal with the shape down to the first wire. With certain reedmakers, there is a slight pinching in after the first or towards the second wire (See P1.VI, No. 4). Its position is variable, as is the shape of the tube below the first wire. Many bassoonists do not use rulers and compasses enough. The result is often a bad fit of the reed on the bocal, corrected by reaming. The effect is also felt in the

PLANCHE V

G.A.M. N° 82 – 83 – LE BASSON (IIIe partie)

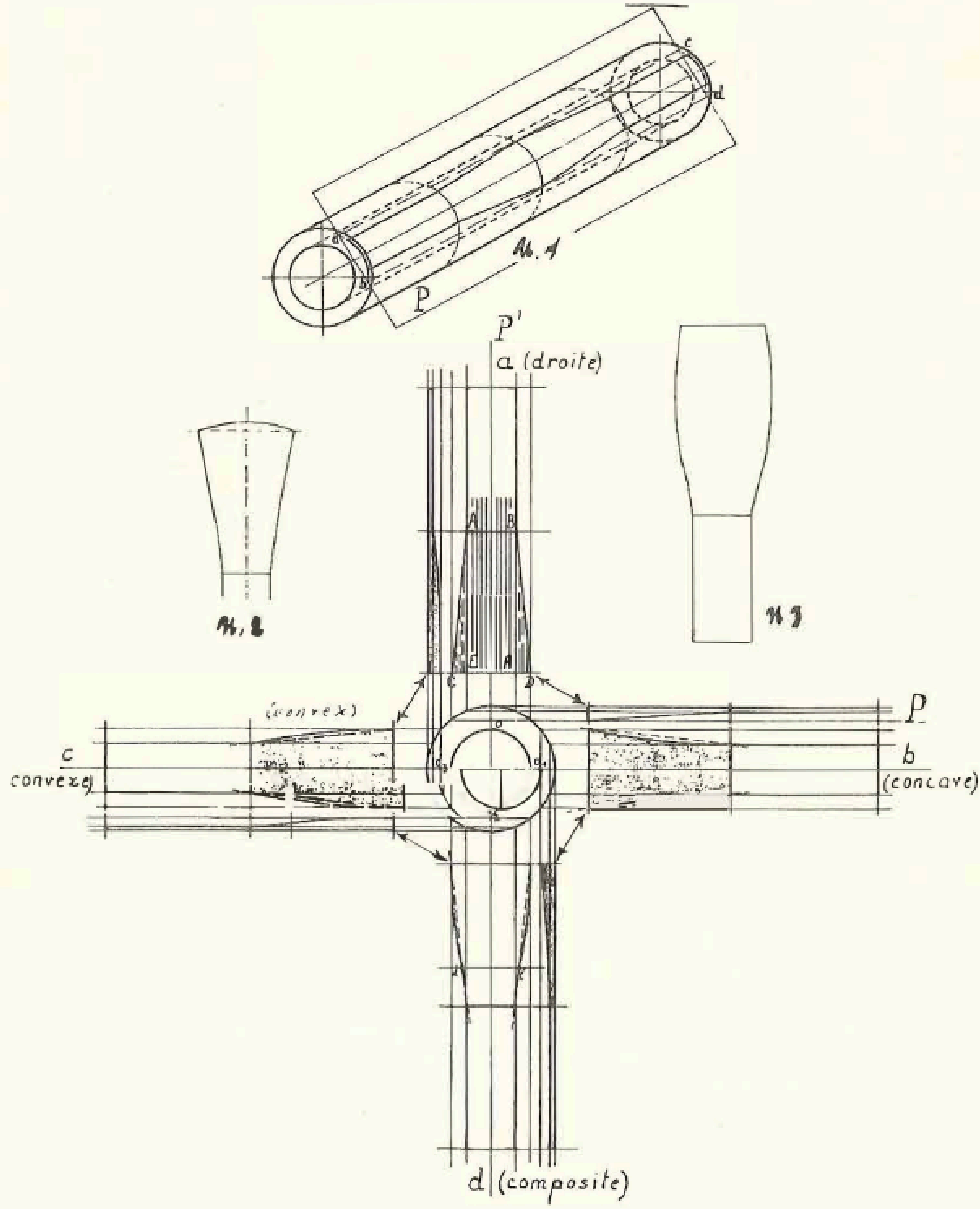
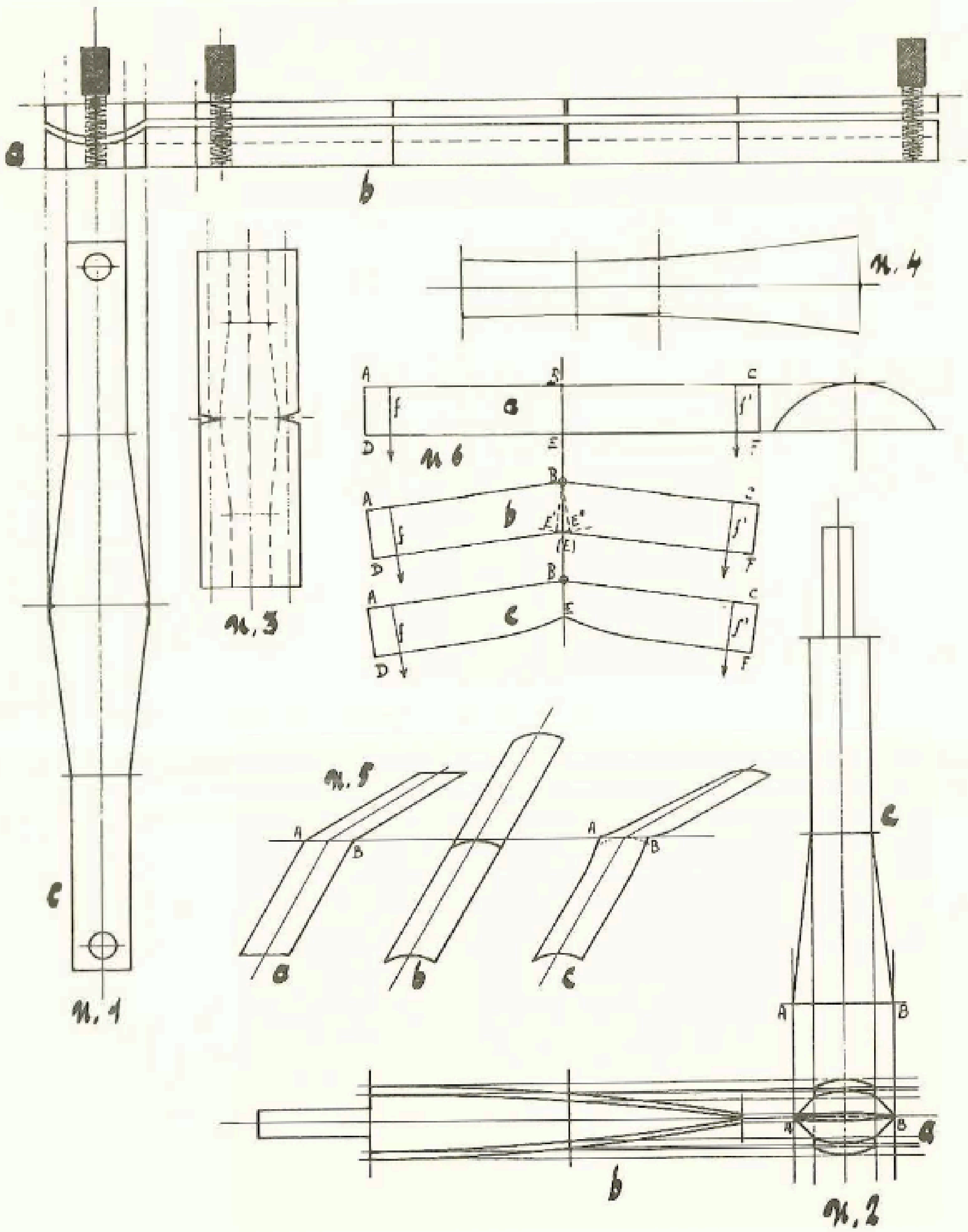


PLANCHE VI

G.A.M. N° 82 – 83 – LE BASSON (IIe partie)



difference of tensions between the blades, and one can question the acoustical effects of a pinched-in first wire. The reed illustrated in Ozi's method book is striking due to its gradual taper and to the width below the first wire (towards the crook).

We return now to the classification of shapes. We make a straight line from the corner of the tip to the side of the back. See P1.V, No. 4 *AC* or *BD*. We obtain an isoceles trapezoid *ABCD*.

a) If the blades correspond to this shape, the shape is straight.
b) If the contour is found inside the trapezoid, the shape is concave.
c) If the contour is found outside, the shape is convex.
d) If part of the contour is on the inside and part is on the outside, the shape is a composite one.
e) Unusual shapes. The tip is always straight.

However, in Diderot's and d'Alembert's encyclopedias, one can see a bagpipe double reed with curved tip (P1.V, No. 2). Though this is not a bassoon reed, we thought the fact worth mentioning. Another type of bassoon reed is interesting because the widest part of the shape is not at the tip but lower down (P1.V, No. 3). Frolich shows narrow and wide versions of these reeds which were in use in the Paris school around 1810. It is a variation of the concave shape still used by oboists today.

The mechanical justification of these shapes remains to be found.

Consider P1.V, No. 4, blade *ABCD*. Between *ABEF*, the fibres are complete in *AEC* and *BFD*. Their length, represented by dotted lines, dimishes towards the edges. One deduces immediately that the relationship between the transversal cohesion of the fibres and the shape is important.

According to our postulate and in order to obtain the tone colour, one must work on the type of tip opening and on the resistance at the sides of the blades. We have not yet spoken of other parameters such as forming, inserting the mandrel, and scraping. With respect to forming, the relationship (to shape) is surprising.

2) Shaping equipment and its effect. There are two ways to proceed:

a) without folding the cane

b) with folding the cane. This has secondary effects.

a) Cutting without folding. We use a straight shaper as seen in P1.VI, No. 1. It is made of two pieces of metal contoured like a reed. The surface between the two sides is contoured like a piece of cane so the cane can be fitted in and held in place. We put the cane between the two sides of the shaper, being careful to put it in straight, and then cut the cane to conform to the shape. With this tool, we can shape unprofiled cane.

b) The Folding Shaper. The cane must be profiled prior to shaping to prevent breakage. One facilitates the folding by marking the centre lightly with a knife (P1.V, No. 5b). The cut is made on the bark side. This is the old method still used today. In former days, one thinned the cane from the inside, as Ludwig does today by machine (see Gouge section). Ludwig, who died a few years ago, shaped by hand, as Ozi did.

Hand shaping must have made experimentation tempting. Frölich advises that once one finds a suitable shape, he should make a tin copy of it to use. Today, we use a folded cane shaper as in P1.VI, No. 2. One can obtain different tips, and interchange them. The cane is folded over *AB* and then cut to shape.

Until a year ago, we used only a straight shaper. After having tried a folding shaper, we found a surprising result – that after shaping, the reed lost much of its curve. Intrigued by this, we tried to find an answer.

Here is the explanation. See P1.VI, No. 5. In *a*, folding a flat rectangular piece over AB poses no problem. In *b*, a problem arises but if the sides of the cane rise towards AB, it is still possible to fold. In *c*, the edges are pushed onto AB and folding is possible from 180° (flat) to 0° (superimposed).

We return to P1.VI, No. 6. In *a*, one sees the cane from the side and head on. Near the edges, we apply a force *f* and *f'* to fold *A* and *C* towards the shaper. *B* is the pivot point. In *b*, if the curve of the cane were not modified, the cane at *E* would have to be incorporated in the other side, i.e. *E* would be at *E'* on one side and at *E''* on the other. This is absurd.

The solution is found in *c*. The edges separate and rise a little at *B*, where the folding angle is greater. Since the sides separate, there is a flattening out. This is a simple explanation of this phenomenon.

For practical purposes is this effect good or bad? We feel that for darker tone, folding is useful. A lateral flattening out weakens and draws together the sides of the reed. This helps one obtain the desired tip opening that closes from sides to centre (our postulate).

We must mention that the wider the cane, the more important the flattening out. P1.VI, No. 3 shows a shape inscribed in a piece of cane. By reducing the width of the cane to the width of the reed, one limits the effects of the folding. By leaving it wide, one accentuates the effect.

Some reedmakers attenuate the effects of the folding by making cuts as shown in P1.VI, No. 3.

Thus, folding is a useful non-negligible parameter. The lateral deformation is permanent unless one tries to re-establish the curve some other way. The problem of folding will gain in importance when one starts assembling the reed. Remember that in this chapter, we dealt with scraped wet cane. We will discuss the scrape later.

VI The Problem of Assembly and the Mandrel

Modern assembly consists of juxtaposing the two halves of the reed, ensuring the proper fit on the bocal, and using the mandrel, giving the two blades an appropriate curve.

The blades react like two springs curved against each other. The system is held by adjustable ligatures.

In the following, we must assume that the cane is already profiled so it can be worked with. A reed can't be assembled unless it is already extensively profiled.

The problems raised are:

a) The fit on the bocal. There are two methods: i) Using a staple. This method is no longer used except by oboists and a very few bassoonists. ii) Modern Method – the complete reed is made using one piece of cane.

b) Reeds can be assembled either with the two pieces of cane folded over or cut apart.

c) Modern method. To support the curve which transforms the end of the cane into a tube, one scores the cane. How many incisions should there be, where, and how widely spaced? The cane is folded and the sides put together to be formed by the mandrel. We again have two techniques. 1) Put on two wires and tighten them. Insert the mandrel opening the wires with pliers if necessary. When the tube is formed, one puts on the third wire and takes out the mandrel. 2) Juxtapose the two blades. Wrap the butt with wet string. We noted that if one wrapped from the butt towards the top, the blades flattened out. If one begins to wrap a bit before the place where the first wire will be and wrap towards the butt, the blades become curved. This is due to the low lateral resistance where the cane is profiled. The blades thus supported, one inserts the mandrel. With this method, uniform distribution of tensions is obtained as well as a well rounded tube. One removes the string and puts on the wires. We will discuss the effect of mandrel insertion.

d) Difference between Buffet and Heckel tubes and mandrels. The tube of a Heckel reed is much shorter. This is because of the angle of insertion of the reed and diameter of the bocal. (Update 9/78. Another reason has been found as well – to be discussed in a future article.) In Fig. 1 P1.X *a*, the Heckel bocal has a smaller diameter than the Buffet one. To obtain angle alpha, the mandrel is at distance *d* from the reed tip. In *b*, the Buffet bocal is wider so distance *d'* has to be greater than *d*. In general with the same mandrel, the longer the tube, the smaller the angle alpha (flatter reed) and vice versa (P1.IX, No. 1c).

e) Reaction of cane to assembly.

Cane is assembled and played when wet. This gives it semi-plastic properties. Juxtaposition of the pieces produces a flattening out of the blades. In P1.IX, No. 2*a*, we see the curve of the tip before juxtaposition. In *b* we see it after. There is a flattening out, i.e. lateral deformation and pressure on both blades.

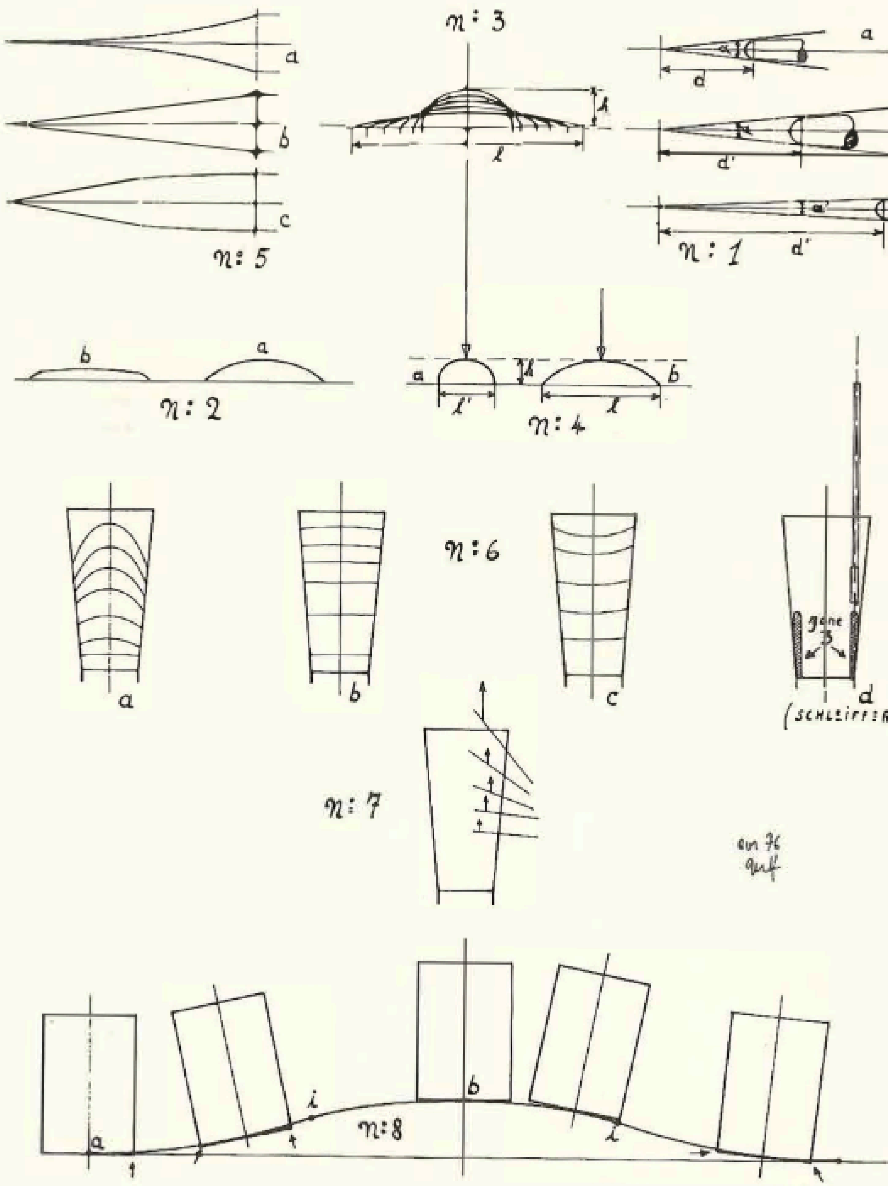
Juxtaposition with a closed tip obliges one to fold the cane. The sides of the blades are more flattened out than before (see Ch. V). If this shape P1.I bis 2 persists after the opening of the tip, according to our theory, the reed would sound rounder than if it resembled P1.IX, No. 2*b* where the edges don't come together easily.

The insertion of the mandrel aside from forming the tube determines the curve of the blades, the longitudinal curve, the crest-line (to be discussed) and the transversal curve Fig. 3, P1.IX. From back to tip the (slope) diminishes as the width increases.

In P1.IX, No. 4, the smaller *h* is with respect to 1, the less pressure is needed to flatten the blades. For the same (1*d c*) – given the same scrape and cane, the convex

PLANCHE IX

G.A.M. N° 82 – 83 – LE BASSON (IIe partie)



reed will be weaker than a concave one (Ch. V).

At the back, the deformation of the cane is such that the cells are crushed (31) and there remains very little elasticity. Towards the tip, the deformations lessen and the elasticity is retained: We ask ourselves if there exists a place in the blades where the original natural curve of the cane persists. From this point, we would have 1) a tightening towards the back 2) a flattening out towards the tip.

f) Problem of opening the tip with respect to time. i.) Open tip assembly gives big tip openings. One must flatten out the wires especially the first. In general, these reeds, not restrained by the closed tip, are more resistant. ii.) Closed tip assembly poses the following problem:

a) If one cuts the tip shortly after assembly this gives a really big tip opening. One must flatten out the reed.

b) If one opens it after several weeks or months, the tip opening barely needs correcting. A phenomenon of "relaxation" has taken place. If the deformation is maintained long enough even within the limits of elasticity, it will persist even after the factors causing it are removed.

c) If one opens the tip too soon (15 days?) the tip opening might reopen widely. One might have to adjust the wires.

One must be careful and know when to start using the reed since the relaxation might affect the transversal elasticity.

One can ask if one should fold the gouged shaped and profiled blank and leave it that way for a year or two before assembling a reed.

Another problem that arises is whether a semi-profile is sufficient or if the profiling should be more advanced. Christlieb remarks that he had better results by profiling while the shaped cane was still on the folded cane shaper. We will return to this in the next chapter.

Here is a note on "vertical variation" (Ch. III) from one end to the other on the gouged, shaped and profiled cane. The structure varies with the length. The extreme variations are superimposed on each other. The two sides react differently to the mandrel and bassoonists always prefer one side to the other. Some reeds are unusable because the differences are so great.

There is an optimal age for reeds. They eventually get old and lose their elasticity.

Remarks on wire: The wires are of steel or brass with varying diameter .6-.75 mm. The wire is not elastic and takes the shape of the reed. It does not vibrate (is there a dissipation of energy?). The role of wires is to hold the blades together so they will vibrate against each other. It also delineates the portion of the reed which must vibrate.

Adjusting the wires. Opening the top wire darkens the reed. The (1 *d c*) rises – this necessitates an increase in pressure to close the reed. The increased pressure of the blades against each other collapses the sides – We come back to the dark reed theory. If the cane is easily worked, and the first wire is very tight, there is a choking at the back which makes the reed appear convex even if it started out straight. If the reed is a success, one must not generalize that this is due to its convexity.

h) Experiments with the (1 *d c*). We took 20 prepared pieces of cane and tried to classify them with respect to degree of lignification. We assembled them using closed tip assembly. We waited two weeks and measured the (1 *d c*) before opening the tip. There were three categories.

1) straight line for moderately (lignified)		IX 5*b*
2) concave line	very lignified	*a*
3) convex line	hardly lignified	*c*

After cutting the tip, we played on these reeds. Apart from the 1 *d c*, we made a table of other commonly observed factors i.e. (transparence). The results were:

1) Degree of lignification determines nature of 1 *d c*. We feel it when inserting the mandrel.

2) Degree of lignification and 1 *d c* does not affect timbre. No generalizations were possible. The darkest and brightest reeds had the same 1 *d c*. These contradictory results remind us of the importance of the transversal elasticity and the theory of Chapter II.

VII The Problem of the Scrape

a) General Observations:

Scraping consists of diminishing the thickness of the cane from the collar to the tip and from the spine to the edges in variable proportions. (This work is the nightmare of many bassoonists.) The preliminary scrape must conform to conditions imposed by the construction of the reed and the introduction of the mandrel. The final scrape must ensure that the tip opening of the reed conforms to the tone quality desired. This last requirement is almost unknown – let us apply our postulate.

We add that the lips impose a pressure on the reed. After even a few minutes of playing, the lips "adapt" the reed to the player. (See previous chapter) We are always struck by this when we play on our own reed which has just been tried by someone else.

One asks if one must be satisfied with only a preliminary scrape or if one can completely finish scraping before constructing the reed. Christlieb's book warns that the results are not good if cane is scraped too thin before reed assembly. If the sides are too thin, (even if they are the thickness they will eventually attain), the throat will be V-shaped instead of oval.

b) Differences between Buffet and Heckel scrape.

The basic Heckel reed characteristic is that it uses only the "soft" layers of cane. To reach them, one must make a shoulder. At that depth, there are no longer layers containing peripheral schlerenchyma or dense parenchyma. We must mention that the thinner the gouge, the more we will have to work with the hard layers of cane. The thicker the gouge, the more we arrive at the softer layers by scraping a lot or by making a deep shoulder. The advantage of the shoulder is that one can have blades entirely made of "soft" cane while retaining strength and support of the reed by leaving all the thickness under the wires.

2) Buffet reed blades retain the peripheral schlerenchyma and dense parenchyma on a large area. Because of this the reed behaves differently. Aside from these differences, the following remarks apply to all double reeds:

c) Adjustment of the reed and scraping principles.

The function of the reed seems to be regulated by the interplay of two elasticities – 1) longitudinal – determines strength of the reed 2) transversal – determines tone colour.

By 1) we mean the geometric characteristics of the centre line –

– its length Pl.1 bis proj *O'O*

– the heights and angle of inclination – *dO'/cO*

also the characteristics of the spine – thickness and variation – and the intrinsic quality of cane for long flexibility.

By transversal, we mean the transversal flexibility from the edges to the centre when we close the reed. The basic quality of cane plays an enormous role and our research is beginning to concentrate in this direction. It is often this suppleness that gives a "smooth dark" type opening even if the reed is badly constructed.

Qualitative observations lead us to quantitative ones. In P1.1 bis 1, one can consider for example the line *ac* as being formed by many articulated segments or by a few rigid ones. The force necessary to close the reed is one thing. Another one just as important is the geometric behaviour of *ac* as it approaches *ao*. This can vary according to the transversal elasticity. In fact, the ideal compromise will be reached by adapting to the inherent cane quality an appropriate scrape to the blades.

The interaction of the elasticities occurs

1) by successive relationships like *ob/oc* from tip to back (P1.1 bis, No. 1). (This explains the importance of the shape. We recall that we mentioned the transverse cohesion between the fibres. These ideas are included in the relationship between tip width and back width.

2) by the transversal variations of the thicknesses altering the way the two blades fit together. The best cane will not play well if the tip is too heavy or too light or if the lateral decrease in thickness from the centre to the sides is badly executed. The type of decrease in thickness is a function of the cane used. – Since cane structure is very different from piece to piece, we would have to alter the scrape for each reed. How can we do this? We will give a guiding concept, by using a family of curves, the point of departure from which is the theory of the spine.

2) Arrangement of "Isopaches"

We found ourselves obliged to consider lines joining points of similar thickness along the blade. We tried to describe the scrape by joining with lines points of equal thickness. Prof. Siestrunk has called these curves "isopaches".

We have an idea of these curves by looking through a reed in front of a lamp. The thin parts are lighter. Along the spine and towards the back where the cane is thicker, the image is darker. All bassoonists recognize the rounded curve that ends before the tip. This area is often called the heart.

Scrapes vary greatly even for the same reed especially after numerous touchups. We don't know if one should scrape symmetrically or not. Some scrapes are deliberately asymmetric.

Here are our findings:

1) If cane is easily flexible sideways, we can content ourselves with cases *b* figure 6 P1.IX. The decrease in thickness from centre to sides is slight. The "isopaches" are barely rounded.

2) If the cane is less flexible and if one wants a dark sound, the sides of the blades must close easily (our postulate). We must therefore thin them down judiciously by making "isopaches" as in (image *a* P1.IX, No. 6). The curve is tighter. If we want a very bright reed we can make "isopaches" perpendicular to the centre line, i.e. the sides will be as heavy as the centre. We can aggravate this further by inverting the "isopaches" (image *c*, P1.IX, No. 6) and make the sides thicker than the centre.

A method of rounding out the reed: In a recent work, Eric Schleiffer mentioned a Zone 3 which we illustrated in (*d*, P1.IX, No. 6). Our theory is that scraping this area involves making a "charnière" that facilitates the proper closing of the reed sides to produce a darker rounder sound. This passage in the Schleiffer book was a pleasant surprise because we had found this out on the "drawing board" by simple deductions rather than after twenty years of trial and error.

We imagine a line going from back to tip parallel to the axis of the reed. To scrape in exactly the right place, we use a thin stick covered with sandpaper and scrape along the lines indicated. On a Heckel reed, the reaction is fast and efficient. Schleiffer's method confirms our observations. On the Buffet reed, this method barely works since the back is so thick. One must arrange the "isopaches" carefully.

The technique and its limits:

1) *Profilers*. These machines copy a model profile on the cane. There are different types. The differences are in i.) the way they cut – they can be hand operated. Ours is this type. Others use planes with a shaft. ii.) Where the model is placed – in some machines beside – in others in the same axis.

Rieger has invented a machine which scrapes assembled reeds. A tiny plane scrapes the blades, especially around the tip. It is guided by the matrix at the back of the reed. This "matrix" is regulated by the bassoonist. The advantage is that it cuts the cane perfectly rather than ripping away cells as does a file or emery board – even the finest. (See Ch. 4 on Kisser's work.) The Heckel reed played for you on 9-1-76 was scraped by such a machine and was never touched with a file. At the date of this printing it is in its ninth month of use and is going a bit flat. This machine is called "Anspitzhobel" i.e., plane to finish the tip. It is a simple machine and has excellent results if the cane is well chosen. We have shown you a slide of the slope (tapering) of this reed. To achieve such a slope (tapering) by hand would take great skill. The machine achieves it every time. Some very sophisticated machines exist, but the results are as aleatoric as those of cane selection.

2) *The difficulty of copying a curved transversal profile.*

Let us consider the profile in Figure 8, P1.IX and try to copy it. A knife that cuts in straight lines, like a plane will only do this with difficulty especially if the blade is big. Between *a* and *i*, the curve is concave and the blade cannot work on one part without one of its edges taking off cane where it shouldn't. Only after *I* will the knife be able to copy the convex curve between *ib*. If one wants a very precise profile, including the point of inflection, one must use a shaped plane or a very narrow blade which would be impractical for other reasons. One must therefore be wary of machines that claim to copy any profile because this is often mathematically impossible.

3) *Scraping by hand – Several features.*

Before shaping the tip, one inserts a shaped plaque which holds the reed securely in place. This facilitiates the work. Often the blades are flattened out more than usual. We can do fine finishing well with our sandpaper covered stick. (So much for the kind of cut – We must choose the lesser of the evils.) We scrape in the direction of the fibres. P1.IX, No. 6d. In Chapter VI we mentioned rheologic problems. We must consider these when we scrape. After scraping, one should use the reed intensively for ten minutes. Often, at first, it does not respond properly, but it gradually improves. If one had continued scraping too soon, the damage might have been irreparable. It is better to let reeds break in slowly over a few days or even weeks.

Certain bassoonists are guided by the transparency of the blades while they scrape. This method is far from infallible. Others work using the feel of the blades as their guide. Some bassoonists have an effective empirical scraping technique – fruit of many years' experience. Only H. Lotsch scrapes according to the shape of the opening (our theory).

Personally we feel that the understanding of the mechanical system that is the reed permits one to work without the ignorance that most musicians face – no principle, no guidelines. Bassoonists we have worked with now feel they understand the mechanics of the reed and work in a more enlightened and relaxed manner. In any case, scraping is not the only cause of success or failure of a reed.

VIII The Special cane selection microscope

This experimental method is aimed at enabling the simultaneous study of the geometry and chemistry of the cellular structure. This is studied in the raw material but eventually this research will be used for the finished reed. The procedure is:

1) Preparation of the cane sample. A section of the cane tube is sawed off as perpendicularly as possible to its axis. This section is then cut with a special knife as if one wanted to make a slide.

We observe not the shaving that the knife has just removed, but simply a cut surface. This operation is rapid but requires a knowledge of how to cut. The cut can be such that even the intercellular spaces of the parenchyma or the tubes of the fascicles appear intact. Seen in a microscope this section does not show much contrast and many details escape attention (even with good lighting). It must be treated by a suitable reagent that must a) be non-toxic b) be trustworthy c) must not penetrate the tube so deeply that it is dyed.

We have this reagent. Besides its non-toxicity, it penetrates 2 mm. and colours only the lignins. The contrast obtained is very beautiful. Preparation time of the cane section is more than 30 sec. including the reagent reaction.

2) The slide tray of the microscope is replaced by a cane holder which is a replica of the one used in a gouging machine. One observes that the transversal section of the cane (i.e. the axis of the cane holder and cane) is a prolongation of the axis of the tube of the microscope. It is very rare that cane fits exactly in the holder. Also, even the curvature of the same tube is not consistent. This shows particularly in the case of the microscope and is an element we must consider.

3) The microscope lens.

a) The enlargement system: It must cover a field the size of a piece of cane at a sizable enlargement. We were supplied with a lens providing a 17 mm. field with a 10X enlargement. The image quality was superb. This fit the requirements sufficiently.

b) The innovation and highlight – the frame. In observing the cross-section of a complete tube, one has no idea of what area will be included in the completed reeds. If the bundle concentration varies with the distance from the edge of the branch, it also varies circularly (oriented right or left). The difference could practically double. On the other hand, the image varies considerably from top to bottom of the tube. The schlerenchyma layer is also variable.

To concentrate on the part of the tube that will comprise the reed, one uses a frame which delineates the portion of cane which will come out of the gouging machine. Consult P1.IV, Fig. 1(a-c). Here is shown a cross-section of the tube as well as the profile arrived at by the gouging machine. This profile gives a kind of window through which we observe the structure of the material. The technique consists of turning the tube slowly in front of the frame (as if the tube were in the mold of the gouging machine) and searching for a good area. The choice having been made, one marks off the area and cuts out the piece.

This is a brief description of our procedure. The problem of construction of the frame is difficult, but the optimum technological solution has been found and the construction will not be too complicated but very delicate. This instrument should be fully operational soon.

An Experiment: We used pieces of cane with widely varying amounts of bundles per unit of area (40-75). We made reeds with these samples and looked for correlations between the timbre and the number of bundles. The results obtained were that there is no correlation between the two. For the second time, we note that the longitudinal elasticity does not determine the timbre. It must be something else – probably the transversal elasticity. The secret is no doubt in the geometry of the location of the bundles and not in the number. Qualitative analysis has led us to quantitative. We are trying to arrive at a compromise between the geometry of the reed and the geometry of the cane structure. (The frame is perfected and each type of reed even from the same gouger has a corresponding one.) Our instrument, therefore, is a compromise seeker. We have theories, but we have barely started our work in this field.

One will object that there are other factors – the wind, the orientation towards the sun, etc. – that we haven't considered. (We think that these factors would apply to a 100 year old tree) but cane grows (in two years) according to certain biological laws which we are trying to discover.

We know cane from the Var is the best basic raw material. As far as ligatures – we find everything – from parallel rows to random disposition. With luck, you will find all this in the same piece of cane. The sun neither stops these arrangements nor stops the cane from being right or left oriented. It is up to us to sort out and find the best orientation.

IX Conclusion

In this paper we hope to have emphasized two points.

1) That the use of the scientific method to help solve the practical problems of reedmaking is possible.

2) That this subject is wide ranging. It has barely been touched on, though we feel it has been approached in a new manner. There is still much to do.

We would like to add two other comments:

1) By admitting that one must go as far as using the electron microscope to determine the quality of a piece of cane one could say that science will not help reed making on a practical level. However, we have talked of simple experiments, of simple geometric relationships and of a simple microscope model whose handling would not be more complicated than that of a marine sextant. If these modest means lead to more consistent results in reedmaking, then we think they are very useful. We will have progressed from craftsmanship to super-craftsmanship. Science will only serve to enhance the artistic integrity of reedmakers.

2) To conclude, we hope that the public will have understood that this is not only a study of the bassoon reed, but that it is also a new way of treating one of the problems involved in a multidisciplinary study. We must consider musicology, acoustics, geometry, mechanics, botany, etc.

This paper could perhaps be used as a course in reed construction that many young musicians could benefit from.

X Appendix

(We have spoken about) The problem of the life span of the reed: A Buffet reed generally has a short life and must be retouched often, while the longevity of Heckel reeds is legendary – (The reed I played on in last year's conference had been used since the previous July and had never been worked on again. We have mentioned Almenraeder's theories on the subject of reed conservation.)

Originally, our research was geared towards finding the cause of the degeneration of reeds. We then realized that reed construction did not have any theoretical basis. In 1970, we changed direction and ended up with the theories we have just presented. We had to set aside the "established principles" and proceed alone.

In 1970 we made comparative studies of the swelling of cane using saliva and using water at 37°C (100°F). We could not agree on the composition of saliva, but it makes cane swell 30% more than water does.

We also inspected and compared microscopically pieces of cane that were new and pieces that had been soaked in saliva for a certain number of hours. The lignins reacted very differently at the parenchymal and schlerenchymal levels of the (faisceaux) and (gaine peripherique) (Ch. III). The saliva seems to have initiated a delignification. The cane became less hygroscopic.

Incidentally, we have noticed the development of fungal colonies in the water in the basins used to soak cane before construction. This occurs if the water is left standing for a few days. These colonies flourish in methylene blue solution. This is especially interesting since we use methylene blue in the labs as an antiseptic!

In short, we have momentarily interrupted this research.

We conclude, hoping that we have interested bassoonists; our research is in their behalf.

FOOTNOTES

[1]Certain artists question the relation between science and music. This is mentioned in the foreword to a conference held on March 14, 1974 at the Brussels Royal Conservatory. This quote seems appropriate: "Ars sine scientia nihil est." (Jean Mignot, 15th century architect) "Art without science is nothing."

[2]People mistake cane for bamboo. For the differences between cane and bamboo, see GAM 71 (Heinrich).

[3]Cane: In German, *Rohrbuschen* (Almenraeder), or *Schilfrohr*. In Italian, *canna*. These are common names, not biological terms. (See GAM 71.) Thus, the ornamental plant canna indica is not cane.

[4]Splitting: Flécher (French), Fresciare (Italian), das Teilen der Rohre (German).

[5]Gouging: Gouger (French), Sgurbiare (Italian), German term in the chapter on gouging.

[6]Shaping: Das Schneiden der Façon (German).

[7]Scraping: Temperare (Italian); for other languages, see the corresponding chapter.

[8]The turk's head seems to have appeared after 1850.

[9]An idea of the success rate is 1 in 10 for oboists, 1 in 4 to 1 in 20 for bassoonists, and 1 in 20 for commercial reeds that work. A development of this point would be almost libellous!

[10]A point which divides a curve into a concave part and a convex one.

[11]This is a representation. Everyone has vertebrae.

[12]Difficult observation; it depends on which level one cuts into these spindles.

[13]Textile uses are limited. Cane is sometimes used to make paper. M. Jansen told us that cane made excellent activated charcoal during World War II.

[14]The innermost layers become the outermost when gouged.

[15]Oboists seem more industrious.

[16]Adjustment is difficult. The sides must be of the same thickness. Therefore, when one obtains the desired profile, the axis of the knife must be perpendicular to the mold.

[17]Observe a stovepipe when the damper is closed. Turn the handle and you will observe that the disc that obstructs the pipe becomes oval, then an ellipse, then flattens out to just a line representing the thickness of the disc when the damper is open. If the damper could move within the pipe while it is inclined and half open, the soot would be collected not in a circle, but in an ellipse as seen from the top of the pipe.

[18]A German from Munich well known before World War II. Opinions are divided.

[19]Not to even mention ellipses and composite curves.

[20]The relationship stems from the angle of inclination (our cutting angle) of the plane of a circle with a non-parallel plane on which the circle is projected.

[21]The sharpening was a disaster – Theory and practice are two different things.

[22]To be judged by the authors who conclude that all gouging machines resemble each other (more or less).

[23]Ludwig played reeds made with cane gouged to 1.3 mm. at the centre with gradually tapered sides while Ozi started at 0.6 mm!

[24]Wide convex shapes regained that pinching in when soaked. They lost their curve when assembled with uncut tip.

Update 9/78 Footnotes 25-29 belong to Chapter V bis which has been left out of this translation at the request of the author.

[30]Also, the thinness of the cane would never allow manipulation tolerated by bassoon cane.

[31]Observing the cane with a microscope is very instructive. The reaction is very unusual.

[32]The small openings spontaneously swell by 1/5 of their dry value. Large ones swell by 2/3 of their initial value!

[33]Almenraeder mentions warping on cane and mentions that it recurs in the reed. He did (rheology) unknowingly. We can compare this to a sheet of paper. It is rolled up and held by an elastic for two hours. If the elastic is removed, it unrolls and flattens out. If the elastic is left on for three months, the paper remains rolled up because of relaxation.

[34]In the first edition of the Ozi method, only one wire is mentioned. In the third edition there are two wires as there are today.

[35]Plate IX, No. 5: *a* – heavily lignified, *b* – moderately lignified, *c* – faintly lignified.

[36]Greek etymology: iso means equal, pach means thick; i.e., a pachyderm is a thick-skinned animal.

[37]Generally these planes go from back to tip. We do not know if sophisticated machines doing the reverse exist.

[38]Plate IX, No. 8. The figure is seen straight on and the plane comes toward the reader.

[39]Trying to test pieces of cane obliges one to cut them out of the tube. Once this is done, it is too late. Cutting 5 mm. away might have led to a successful reed . . . .

[40]A Dutch biochemist, Dr. Hember of Maastricht sent us the results of his research on reed conservation and we are thankful for it. The cause of disintegration of cane is due not to the bacteria themselves but to the enzymes secreted by the bacteria. These enzymes attack the constituents of the cell walls.