Laboratory Notes

PALATOGRAPHY

Although I am by no means a specialist in this branch of Experimental Phonetics, I wish to suggest a slight modification, which I think presents some advantages, in the process of palate-making, as described in the theoretical works, and as I have seen it carried out in various laboratories.

The usual prescription, after the first coating of Ouranine has been given to the mould, is to form a support for the following layers by means of thin flakes of absorbent cotton wool. It is, of course, next to impossible to obtain a palate of uniform thickness by such primitive means, the choice lying between a shell considerably thicker than need be (which presents obvious disadvantages) and one bordering on a sieve.

My humble remedy simply consists in substituting for the cotton wool some kind of muslin or gauze. What I have actually tried for this purpose is tarlatan. The dressing is removed by a brief soaking in water, and the tissue can then easily be got to follow even the minuter intaglio lines of the mould. The successive layers of Ouranine are superposed in the usual way.

It may be objected that there will be a tendency to shrinkage, which may affect the shape or the size of the palate. My own experience in this matter is not sufficient to enable me to form a definite opinion. In any case, it ought to be possible to use some of the unshrinkable tissues for the purpose set forth. I leave further experiment to palatographic specialists, but it seems to me high time to improve upon the rough-and-ready cotton wool method.

However, the real difficulty with which palatography will probably have to contend in the near future lies in a different direction. Owing to the death of Montalbetti, who had the monopoly of Ouranine, no supply of this useful substance will henceforth be available, and it will become imperative to seek for a substitute. M^me^ Montalbetti offered me the remainder of her stock — a few bottles only — about a year ago, and she did not appear to be acquainted with the formula. The deficiency will, of course, be made good in time, but meanwhile considerable experiment may be required before lighting upon any equivalent compound.

TAMBOUR MEMBRANES

It may be taken that the substance at present most widely used for the purpose of capping Marey tambours is the fine condom caoutchouc of commerce. This material is very much affected by climate : it will not bear passage through the tropics (— so experience in Australia taught me —), unless specially packed, and prolonged exposure to the air in any country deprives it of all elasticity and strength. At Montpellier we were never able to keep it in proper condition for any length of time, owing to the damp sea wind which, whenever it blows, is the scourge of Lower Languedoc; and at Barcelona, where the average moisture is yet greater, matters are no better. However, when fresh, this type of India-rubber appears to present (— we must speak cautiously, for tambour membranes have not so far been exhaustively studied —) innumerable advantages over less elastic and delicate substances.

One of its most striking properties is its ready *sonorous* response, when set in vibration under certain conditions. With a suitable degree of tension, for example, it will reproduce any notes (comprised within limits ascertainable by experiment) that may be sung into the mouthpiece connected with it by tubing of indefinite length.

Prof. Grammont and myself were so much struck by the extremely ready response of a membrane, which I had chanced to stretch to just the extent requisite for the purpose, that we undertook a series of experiments, with a view to forming an

estimate of the acoustic effects it could furnish. Speaking or singing in the same room as the membrane under inspection being a seriously disturbing factor, we employed a considerable length of rubber tubing to connect the tambour placed in the laboratory with the staircase leading to the lecture-room below. The windows and door of the laboratory were closed, the tubing was passed through the key-hole, and Prof. Grammont took up his position downstairs at the entrance of the lecture-room, while I stayed upstairs in the laboratory to listen to the membrane. Prof. Grammont began by humming a hunting-song of limited compass. The effect was almost the same as if he had played it on a *mirliton*. He next, without warning me, proceeded to recite some great French verse, which sounded like musical *recitativo*. Of course, the *timbre* was in both cases unattractive. Further experiments, in some of which we exchanged parts (— he listening, I speaking or humming), confirmed our first impression. We were unable to prosecute our investigations to a point where they could be expected to yield accurate data, owing to Professor Grammont's unavoidable absence.

The results, such as they were, we considered important. In the first place, the great resemblance between the melody of French verse — when properly recited — and actual song, so noticeable because our arrangement stripped the verse of all its surds and destroyed the musical *timbre* of the singing, could not fail to impress us, as we were keenly interested in that question and had examined it by other methods. What struck us most, however, was the fact that membranes of this type automatically provide the means of anral control so highly prized by the various experimentalists who have caused the speaking-machine, in one form or other, to play an essential part in their methods of speech-recording, and have made out the lack of this control to be the damning feature of all kymographs. Of course, these gentlemen are usnally careful to say that the Marey tambour probably responds correctly to the fundamental tone, and we have expressly stated above that tone-colour is ruined by the membrane; still, we have gained this much, that we can now object to their too categoric affirmation that investigators who nse the kymograph have no possible means of controlling their

graphic records. A good ear can control the record *while it is being made*. If one is very anxious about the permanence of the record, it is quite feasible to take a phonogram of it at the same time, but, in many cases, all that is desired is the assurance that the kymograph is not recording Chinese song while we are supplying it with Hottentot speech.

That the kymograph does not record *timbre* adequately is admitted on all hands, but it has some practical advantages, too well known to require specification here, when used for other purposes than the arduous study of tone-colour. We claim to have suggested a means of control, by which it can be cleared of the unjust imputation that it probably writes none but the most fanciful stuff, devoid of all basis in fact.

MEMBRANES & MOUTHPIECES

It was mentioned above that the type of membrane there described would respond to notes within certain ascertainable limits. The determination of this «compass» of the membrane employed is a matter of considerable practical consequence. It is usually overlooked in making ordinary speech-records, because, under normal circumstances, their compass is very limited. This is still more the case in reciting serious verse, where it is quite common not to exceed a total compass of a sixth or a seventh for several consecutive stanzas. Of course, much depends on the nature of the verse, but, in the chief specimens of the best French poetry (— with which form of diction I have been mainly concerned for some time —), an interval of a whole octave is a comparative exception, save, naturally, when the meaning requires a dramatic effect.

I had therefore never taken systematic note of the fact that there is a «compass» which a given membrane cannot exceed, until I was rudely awakened to the realities of the case by a trying, although interesting, experience at Barcelona. It must be premised that the «compass» in question is to be understood as that of sonorous response. Like that of some wind instruments, it can be slightly forced upwards by increase of breath-pressure. It should be added that, above the limit of sonorous

response, it is possible to get the membrane to vibrate sufficiently for the purposes of graphic recording, bnt at the expense of inordinate pressure.

Taking advantage of the Liceo season, I had asked Mlle Vix, the eminent French singer, to favour me with a kymographic record of one of her chief arias. After experimenting with the apparatus for a couple of minutes, her native quickness picked out three salient features of our machine for «photographing the voice». — «It is next to impossible to sing into a mouthpiece which does not allow of opening the mouth properly; the membrane does not respond to any of the higher notes; *r*'s alone seem to make the pen stir : shall I sing you a song on *r*'s throughout?» — I foolishly declined, knowing the difficulty of taking measurements on *r* records.

Of course, these criticisms slightly overshoot the mark. The *r* is not the only phonemon which sets the lever in vibration, but it is certainly the one that does so most readily to the naked eye. Again, it is not quite impossible to get the membrane to vibrate to notes of high pitch, but the pressure required is unpleasantly great for the person singing. As for our mouthpieces, we manage to get results with them, although I confess to thinking that they deserve almost unmitigated condemnation.

In saying that the membrane can be made to vibrate on the higher notes, we do not mean that its compass of *sonorous* response can be increased in any considerable measure. This, in the case of a given membrane, appears to be almost fixed, the upward limit of response coinciding with the change of register in the voice. As one and the same membrane will behave in an identical manner, whether sung to by a male or a female voice, and will ignore the difference of an octave separating them, it seems not unreasonable to suppose that the mode of production is the main factor on which the responsive or negative attitude of the membrane depends. In any case, this peculiarity of membranes, if correctly observed, as I think it was, is a very remarkable one.

Why not attempt to solve the question by asking a professional male singer to sing up, beyond the break, in chest voice acquired by study? Because singers cannot be got to sing into

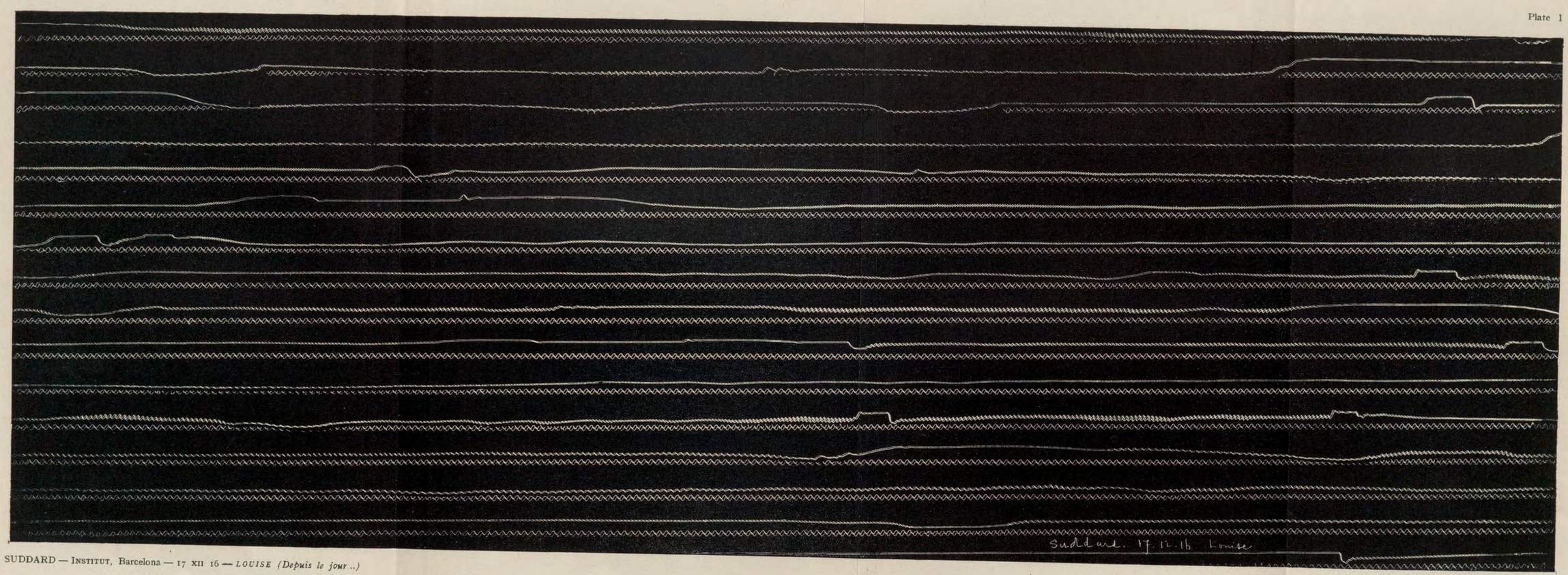
our current mouthpieces, either to their own satisfaction or ours. They object that the mouthpiece prevents any proper singing, and we complain that, in opening their mouths to obtain the fine tones they alone consider singing, they allow the breath to escape out of the mouthpiece, and the pressure to diminish below the minimum required to affect even a seusitive membrane.

The first requisite, before proceeding further along this line of experiment, is, therefore, a mouthpiece that a singer can reasonably be asked to use. Rousselot, familiar with the difficulty, describes in his *Principes* a substitute for the mouthpiece, in the shape of a kind of tambourine, but the records it gave him can hardly be called encouraging, and such an arrangement would be of no service in investigating the problem of the sonorous membrane, where wind-pressure is indispensable. What should be the shape of a good mouthpiece, I do not know so far, and it may well be surmised that the problem will not be too readily solved. I presume the conformation of the face in the person for whom it is intended will prove to be an important factor. I have seen many different shapes of mouthpiece in various laboratories; the one M^lle^ Vix was asked to try was the best I have come across : it served me personally to make the records shown in Plates I, II, & III, and yet it proved so unsuitable for her that the attempt had to be abandoned.

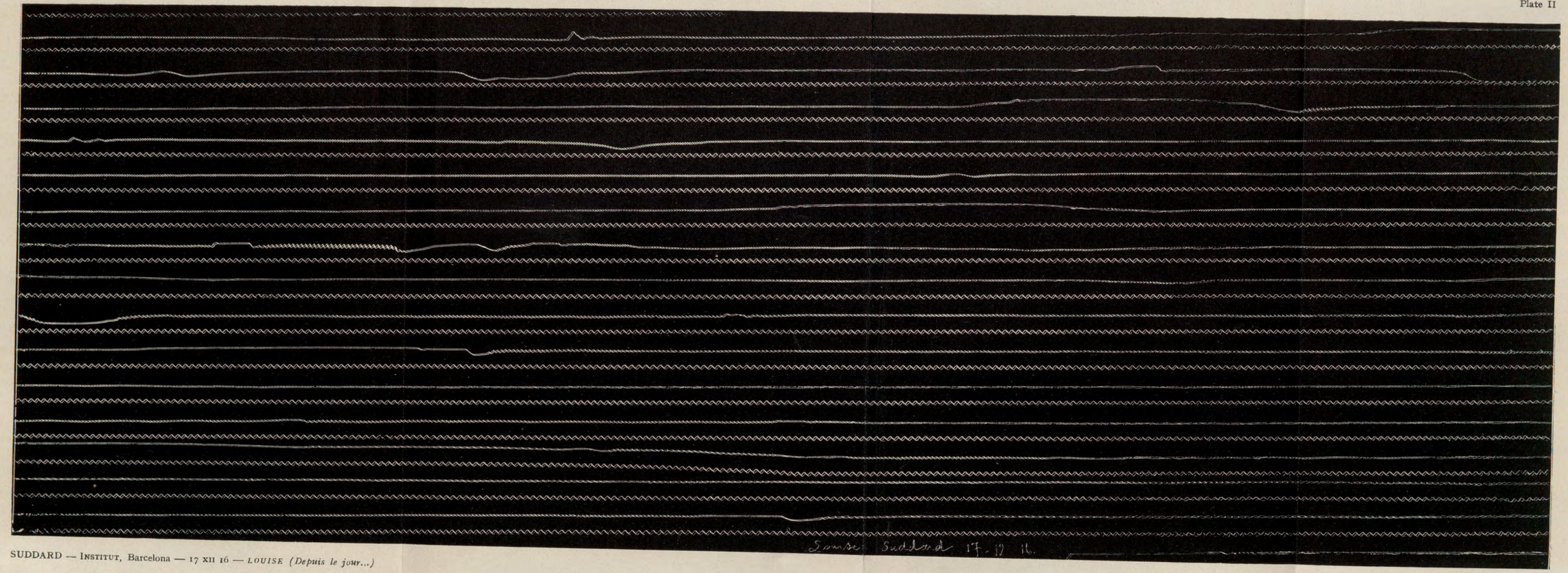
And why, it may be asked, trouble about kymograph records at all, under such circumstances? Why not do Struycken work instead? The answer is, partly, that the Struycken apparatus involves photographic recording, which is open to some objections. However, the immediate practical reason for not at least trying it, in the case referred to, was that we had not yet received an instrument of this type. It had been ordered a considerable while before, but had not reached Barcelona at the time of my experiments.

TRACING-STYLES

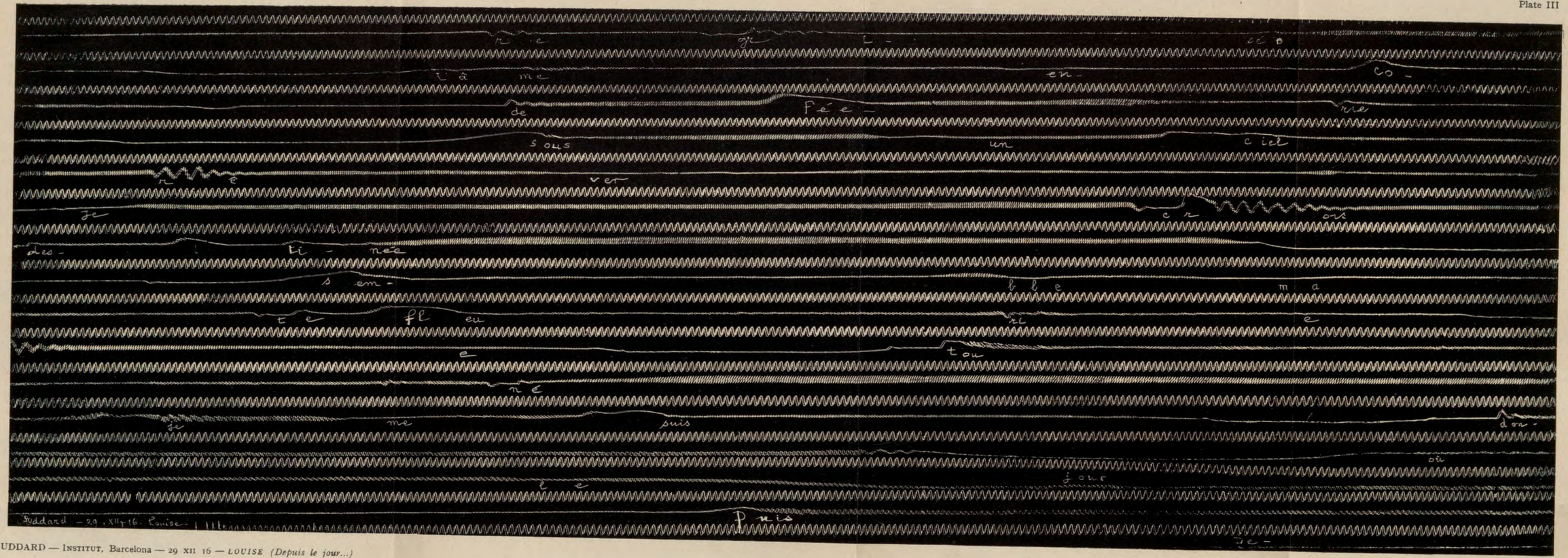
Tracing-points for recording on smoked paper are made of many substances. Gold leaf is not quite the worst, although almost its only real quality is the absence of resistance offered to the writing-surface. As for its vaunted ductility, the truth



SUDDARD — INSTITUT, Barcelona — 17 XII 16 — *LOUISE (Depuis le jour ..)*



SUDDARD — INSTITUT, Barcelona — 17 XII 16 — *LOUISE (Depuis le jour...)*



SUDDARD — INSTITUT, Barcelona — 29 XII 16 — *LOUISE (Depuis le jour...)*

is that it breaks somewhat easily; and the advantage of being able to cut it to a fine point is very much attenuated by the practical fact that looking at it will almost suffice to crush the delicate pen into a miniature hoe. It is also inconvenient to mount on the straws.[1] However, with very great care and finer adjustment than is usually feasible on the relatively coarse apparatus the makers have so far been in the habit of getting us to put up with, gold leaf will furnish pens capable of tolerably high-grade tracing. The other substances commonly employed in its stead need not detain us, but a word of protest against brass and copper writing-points for electrically vibrated tuning-forks will not be out of place here. When used to write on sheets wrapped around brass cylinders, these metal pens purely and simply bring the fork to a stop before the sheet is half finished, —for the evident reason that the current escapes into the cylinder, unless, being derived from accumulators, it is of such power as to make the laboratory windows trepidate.[2] To the use of currents stronger than necessary, there are serious objections, on which we will not dwell here. The true remedy consists in making the style of some non-conducting substance : a quill tooth-pick will do.

Anyhow, it is evident that much less care is usually bestowed on the action of the tuning-fork style than on that of the tambour pens. Why? It is doubtless assumed that the force of the current will overcome all obstacles, whereas it is quite realised that very little suffices to exhaust the propelling power of vocalised currents of air from nose and mouth. That the tuning-fork cannot safely be treated in this rough-and-ready manner, I have shown *ad lib.* elsewhere. Not only are the pens used (including the quill) quite unsuitable, giving rise to friction enough almost to set the apparatus on fire, but the mode of mounting the fork on the chariot is generally unsatisfactory in every way. Owing to its considerable weight (—much reduced in Zimmermann's models), the fork is usually fixed on an upright standard

1. Never use secotine for this purpose. That literally filthy substance is fit for none of the finer work of a laboratory.

2. This easily happens in the case of forks with mercury contact.

of the travelling chariot, where it cannot be swung back and forth or up and down, the almost inevitable consequence being the ruining of the writing-point.

It was with a view to finding a substance more supple, and therefore less sensitive to rough usage, while at the same time offering less resistance and consequently giving rise to less friction, than a quill, that I experimented with various materials, finally pinning my faith to gelatine. This product, so beautiful in the higher grades used by confectioners, etc., can be had in many thicknesses and several colours. The difference of colour may be taken advantage of to distinguish one pen from the other, if several are used. Gelatine can be cut to as fine a point, I believe, as gold, over which it has innumerable advantages. It is possible, by applying force, to give it any desired fold, and therefore to make it touch the writing-surface at any angle preferred. Yet it is sufficiently elastic (in certain thickuesses) to return to its position, despite any amount of fortuitous deviation. The fine points that can be given to it are not readily blunted, and never crushed, as those cut in gold leaf are so apt to be. It is extremely easy to manipulate and mount *in* the straws.[1] It can be employed in much longer strips than gold leaf, from which a satisfactory pen an inch long could never be cut . This is a matter of consequence in the case of the tuning-fork, to which a very small pen is difficult to fit, and which, if incapable of any swinging motion, requires a style of moderate length and elasticity, in order to compensate for its own rigidity. The gelatine points, when freshly cut, are somewhat rough and scratchy. I remedy this empirically by passing them once or twice gently across the slightly moist surface of glycerine soap, from which the water has evaporated (after use for washing) to the extent of no longer leaving a shine on the tablet. Substitutes for this treatment have failed entirely. Gelatine is very sensitive to moisture : if wet, it can be shaped easily, but it loses its suppleness and elasticity. The pens must also be kept away from the heat of the smoking-flame, or they will shrivel.

1. They should be split open along $^1/_4$ in. of their length, in order to receive a blade of gelatine, which a trifle of gum arabic keeps in position.

DOUBLE PENS

About a year ago I first began to extensively use the double pen, a notion which had occurred to me some time before. Although I had been using gelatine for pens since the previous year, and yet longer for another purpose described further on, I began by making the double pen of two gold writing-points of the usual type. The reason was, if I remember aright, that I despaired of cutting two small styles, in the somewhat stout gelatine I happened to have at my disposal just then, with sufficient delicacy to be able to gum them together, so as to overlap each other, and then fit them into a straw carrier. The gold pens did not prove satisfactory, owing to the great liability of their points to accidental crushing. The results they gave sufficed however, when conditions were favourable, to fully demonstrate the feasibility of my idea. Having no suitable substitute for gold leaf, I decided to alter the shape of my twin pens, converting them into one double pen and cutting them out of a single piece of gelatine. This was the true solution. The procedure is as follows : take a small strip of gelatine; cut it very much as you would a quill pen, but with a small pair of sharp scissors instead of a penknife; split it in the same manner as a quill, and fold down the points until they form an angle of, say, 120° with the rest of the strip; clip one of the points just a trifle shorter than the other, and bend it inwards, so as to form an angle of very slightly smaller aperture; introduce the blade of a knife into the slit between the two points, and separate them by a fraction of a millimetre. The double nib is now ready to be gummed into the straw carrier. If the operation has been correctly performed, the two points will touch the cylinder at a minute distance apart: one will be a trifle in advance of the other, and one will also be slightly to one side of the other. When the chariot bearing the double pen is moved across the cylinder while at rest, two fine lines, a fraction of a millimetre apart, should appear traced across the smoked surface; and, when the cylinder is rotated, a similar double line should run around its circumference, spirally, of course, if the chariot is advancing at the same time. It cannot be too much emphasised that the distance between the two par-

allel lines should in either case be extremely minute, if the object of the appliance is not to be defeated, as it is in some parts of the figures intended to illustrate this paper. The notion is, of course, to obtain two simultaneous records slightly interfering with each other. The difference of phase ensures the mutual crossing of the two pen-lines at certain points, and these points serve as landmarks, in measuring individual vibrations, or small groups, under the microscope.

It is thus no longer necessary to know exactly where a vibration *begins* and *ends*, because it suffices, in most cases, to take the measurement from one point of intersection to the following. The increase of friction is, I believe, negligible, when the pens are delicately adapted, and may be reduced practically to vanishing-point by using ever thinner gelatine, which will also yield more and more delicate records. The surface will naturally require to be very slightly smoked, and such records will not bear reproduction by the ordinary methods of photogravure. For the purposes of illustration, we have therefore been obliged to choose extremely coarse records (Plates I, II, & III), with much too wide a space between the two pen-lines. A trifle more delicate are some of the examples on sensitive paper (suppressed), but it is possible to do yet more minute work. The double pens which gave these tracings were made of relatively stout gelatine, because it happened to serve our rough-and-ready purpose better than the thinner varieties, which naturally call for somewhat more careful manipulation and minuter adjustment. As for the fear that confusion may arise, owing to this frequent intersection of lines, examination, under the microscope, of any double tracing materially successful shows it to be groundless : an objection of this nature can have only popular validity.— But, it may be said, in some parts of the records shown in the plates, the two lines do not intersect. — No; if the adjustment is coarse, the double pen fails to answer its purpose, wherever the vibratory amplitude is small.— Is it possible to make a double pen sufficiently fine not to get very minute vibrations into a hopeless tangle? — Yes, by using the thinner types of gelatine, recording on a smooth and slightly smoked surface, and judging the result under a good microscope only.

TRANSLUCID RECORDS

As we are speaking of microscopic work, we may mention that the *couché* paper, ordinarily used as a support for the layer of smoke in which the tracing is made, is, in our opinion, one of the unsatisfactory elements in kymograph records. No doubt it is tolerably smooth, offers but little resistance to the writing-points, and can bear heat and fixation in an acceptable manner. But this glazed paper, being relatively thick, forms a bulge, when lapped for the purpose of gumming; it curls inconveniently during fixation, and usually cracks along its edges afterwards; it is practically opaque, and this is its capital defect, for it makes it difficult to study under the microscope, unutilisable for projection[1] and photomicrography, and almost so for direct printing off on to sensitive paper. It can, it is true, be rendered slightly more translucid by suitable treatment during fixation, but the operations involved are unpleasant and unsatisfactory, the preservation of the sheet usually becoming impossible in consequence.

To remedy this defect of opacity, I began, a number of years ago, at Montpellier, to experiment with various kinds of translucid paper. One type of tracing-paper, although far from perfect, was found to give tolerable results, and we have used it ever since for records intended for the microscope. It is cheap, thin, glazed, bears heat and fixation, and is all that can be wished, as far as translucidness is concerned, but it has one grave defect. Although glazed, it is not strictly flat, but gently undulates all over its surface, which thus presents the appearance of countless hills and hollows. This relief is of an order of magnitude such as to appear at first sight negligible, but, when it is remembered that we wish to be able to take measurements with an accuracy of 1 μ (or, at any rate, of 5 μ), the objection becomes much more serious. Smoking and fixation do not improve the surface, in this respect, — rather the reverse.

It is therefore imperative to find some other translucid mate-

1. Projection of tracings on opaque paper is, of course, possible with the epidiascope, providing the illuminant is sufficiently powerful.

rial suited to the purpose. I first tried gelatine for records a couple of years ago in Australia. It does not take fire like celluloid, nor does it shrivel up, if properly stretched around the cylinder, and fixation hardly affects it at all, as far as I could observe. But, although it does not shrivel away to nothing, when it has an uninflammable support to stretch it evenly, still it does not bear heat well. After smoking and fixation, it presents the same appearance as the tracing-paper sheets,— often in a more marked degree. It is also somewhat unmanageable, when it first comes off the cylinder previous to fixation, showing a provoking tendency to behave like a clock-spring. However, it is so perfectly transparent and so highly glazed (— therefore offering little resistance to the pen —) that we cannot make up our minds to definitively condemn it for the use in question.

Translucid records, when used in the same way as ordinary photographic negatives, yield capital prints, in which the tracing appears in black (or other dark colour) on a white background. Some specimens of this type of work are seen on Plate...,[1] which also illustrates the relative delicacy of tracing easily obtained with gelatine pens. Several of the examples exhibit double pen records, although not always satisfactory ones. A number show tracings from two independent tambours fitted with single pens writing in practically one and the same path, breath-pressure causing them to occasionally cross. This device may at times prove useful, if the resulting record is examined by the aid of coloured films with perpendicular cross-lines (as described below).

Transparent tracings with a single pen may also be printed off in such a way as to furnish two different images slightly interfering with each other, the effect being much the same as that yielded by the double pen. No illustration of this method is offered here, there being considerable practical difficulty in printing off, in this way, a large number of copies on sensitive paper, the displacement of the surfaces for the obtention of the second image requiring to be performed with mathematical nicety.

1. This plate has had to be suppressed, owing to an accident.

MEASURING DEVICES

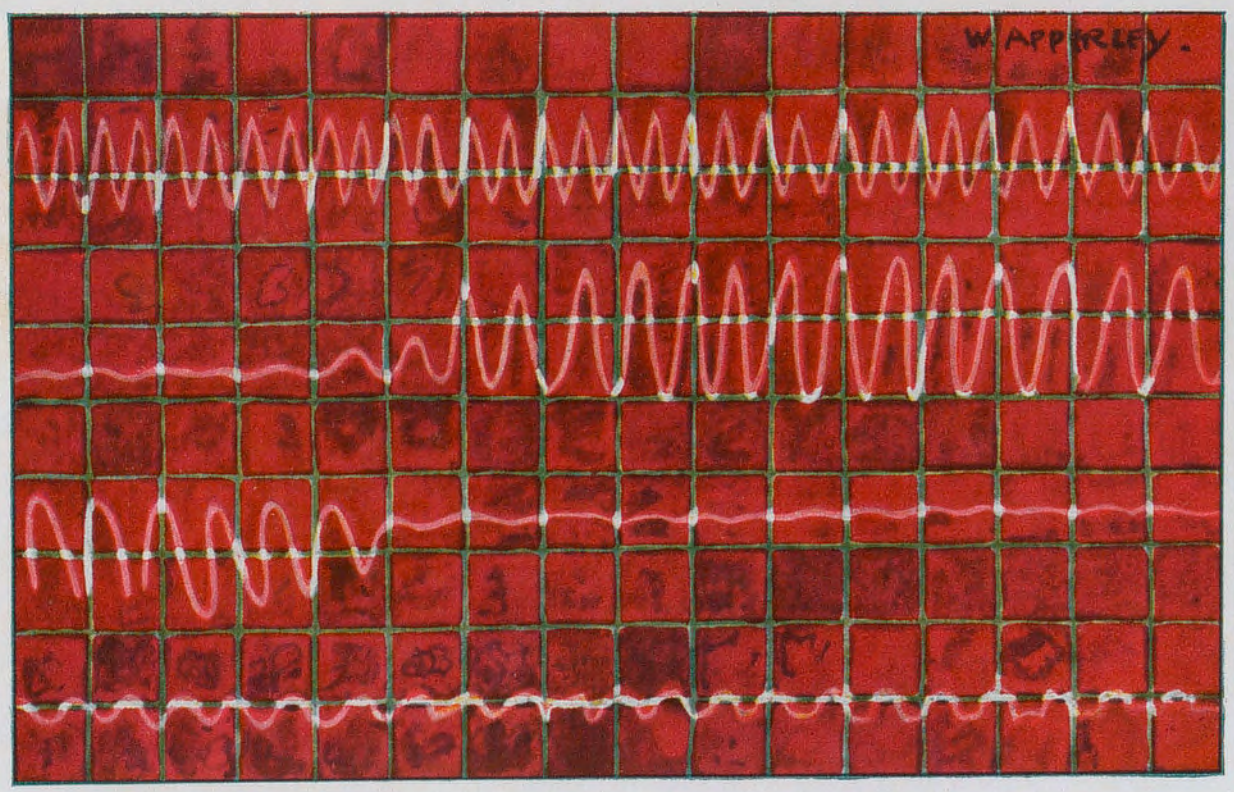
In order to obtain «accurate» measurements of vibration-lengths, a theoretical prescription tells us to draw a straight line through a series, and then take the points of intersection as a basis for further work. We would not quarrel with the method, if it could be applied in practice, but any one having had experience with phonetic records knows that it is almost always inapplicable to them, the variable breath-pressure causing our records to run anything but straight, and the vibrations being too minute for such treatment.

Tuning-fork vibrations of considerable amplitude are the only ones occurring in our sheets that can be dealt with in this manner. Even then, if it be attempted to literally draw the line on the record, there is the difficulty of the surface, on which it is next to impossible to mark anything, let alone delicate lines.

The need of marking the records may be obviated by drawing the line on a transparent surface, which is then placed over the vibrations, with the line in immediate contact with the tracing. The line might be drawn in Indian ink on tracing-paper, but it would be a very flimsy, uneven device. Practically no substance but glass is strictly flat and transparent, the only trouble being about marking it. As it is exceedingly difficult to paint a line of any delicacy on glass, the best solution seems to be to use the diamond. The ordinary diamond does not give a very clean line, but specialists could engrave anything to order. Let us now put our glass plate over the tracing to be examined. The great advantage of a movable line, which can easily be displaced and adapted to all the freaks of the curves, will soon be realised. The excursions of the writing-point being sometimes very considerable, the convenience of a second line, so as to avoid too much shifting, suggests itself. A third might not be useless, and a few perpendicular lines as points of reference. This is the substance of the device, but in such an elementary form it is not very serviceable. The lines scratched on the glass do not stand out brightly. In order to obtain real distinctness, colour is needed. The glass is therefore coated with a transparent coloured film,

on which a whole net-work of lines, not necessarily equally spaced, can be drawn with a penknife. When this plate is placed on the stage of the microscope, the lines do not appear white, although the knife reached the glass in every case : they assume the colour complementary to that of the film. Plate IV gives some idea of the appearance of a record on translucent material seen under such a film, although microscope manufacturers rarely favour us with such an extensive field. The contrast of colour is helpful, but the most interesting point is that, wherever the transparent lines of the network cut the highly translucent tracings of the record, the point of intersection is brightly illuminated. This has many advantages. Among other things, it suggests processes of measurement of a type analogous to that described by Wilh. Schmidt in the *Zeitschrift für Instrumentenkunde* (Vienna) for February 1915. It will be noticed that it is easy, by slightly displacing the net-work, to cut the vibrations in every conceivable manner. In some forms of vibration it may be convenient to, so to speak, cut off the heads of a series, by placing them in a streak of light. It may make it easier to judge their true length. Schmidt's method, which refers to very flat curves, can be applied to them better, I think, in this manner than in any other, on account of the great advantage of transparency in all the elements of the arrangement.

It is convenient to have a number of plates of different colours. By putting one below the record (— where it is generally advisable to have at least a plate of clear glass, which along with the top plate keeps the record flat —) and another of a different colour on the top, more complicated combinations can be obtained, and the possibility of displacing the two plates, in their relationship to each other, may prove useful on certain occasions. It is better to have net-works of different degrees of closeness, down to the millimetric model. Those with unequally spaced lines are often the most convenient. Lines at all angles can also be drawn on the film, as well as circles and other designs for purposes of delimitation. Numbering the perpendicular lines is important, when the record is any length. The films *cannot* be marked while in use, as they must always be in the closest contact with the record, if they are not to be badly out of focus.



SUDDARD — Alicante — March 1917 — *COLOURED FILM (Magnified)*

An ordinary ocular micrometer is, of course, indispensable for actual measurement.

As for the film, I do not know how it could be manufactured industrially. For tentative laboratory purposes, I will describe my own method, adding that the main defect of films thus prepared is their tendency to dim, if not carefully handled. Canada balsam not being snitable for the purpose, owing especially to the uneven manner in which it takes the dye, I made my first films with white of egg, but later adopted blood-serum.[1] The plate is cleaned with alcohol, flooded with serum (which is drained off, so as to leave as equal a coating as possible), and put to dry in as warm and dustless a place as may be available. When dry, the film is fixed by flooding with alcohol. It is now ready for use, unless, by fixing and drying several times, it should be desired to harden it further. The next operation is the colonring of the film. I have attempted it practically with the anilines only. Ziehl's Fuchsine formula gives beautiful results, as far as red is concerned. I have also made blue films (Methylene blue), green films (Methyl green), purple films (Gentian violet), flame-coloured films (Picro-Fuchsine), etc. It is essential that the dyes should be of a high grade. Those I have mostly used are from the firm of Dr. Grübler (Leipzig). The film is flooded with the dye of the strength desired (containing a mordant, such as carbolic acid), and, after a little rocking, the overplus is drained off. The plate is then left to dry, whereupon it may seem so pale as to require a second dose of colour. When once the film has been satisfactorily dyed, it is well to let it alone. In no case should it be treated to alcohol and water, after the dyeing

1. For the sake of readers who have never prepared blood-serum, we will give the simple directions for its obtention. Take an 8 oz. flask to the slaughter-house — that supreme disgrace of our civilisation; ask to have it three parts filled with blood, and add some glass beads, with which shake up the liquid, to keep it from coagulating. It does not remain fit for use above a few hours, so it will be necessary to fill two or four of the sedimentation tubes for the centrifuge without too much delay. This quite simple instrument will then whirl the tubes around in a circle for a few minutes at a considerable speed, after which the serum can be drawn off with a pipette. It is better not to insist on getting too much, as the least stirring of the precipitate, the slightest consequent turbidity of the serum, is translated into stains in the later process of colouring.