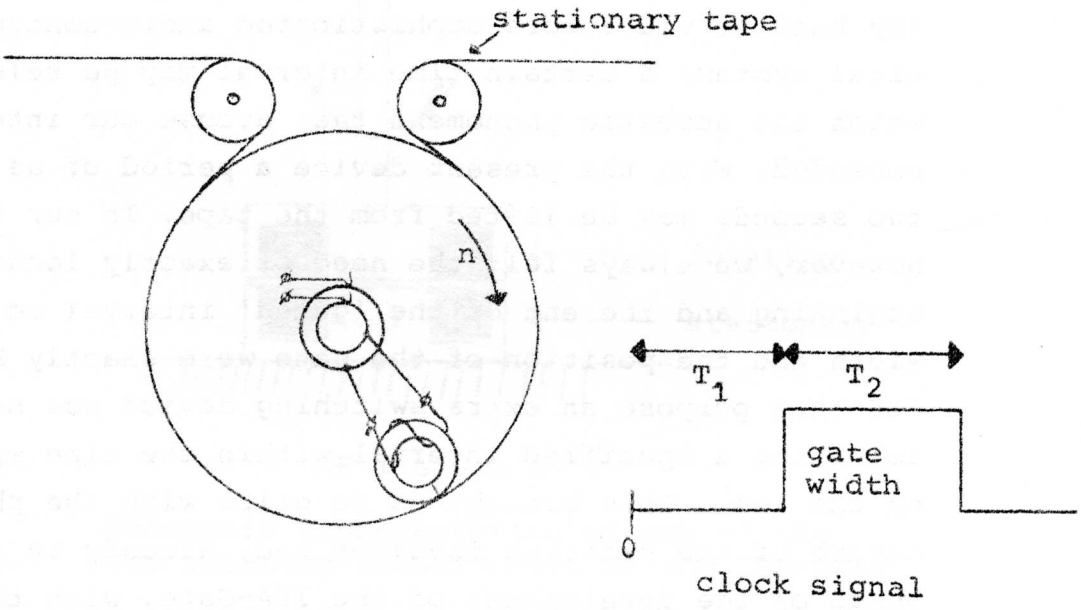
## The IFA-GATE 1973

A report by H. Mol

Since around 1958 experimental phonetic research at the IFA is greatly influenced by a gating technique based on the recording of speech material, including running speech, on a magnetic tape first, and afterwards scanning the tape in a stationary position with a rotating reproducing head. My private infatuation with rotating heads took root around 1955, after I read the Bell System Technical Journal. As figure 1 schematically shows, the head is mounted in a rotating cylinder, around which the stationary tape is looped.




F I G U R E 1

The technique of the rotating head, represented schematically.

The reproducing gap, moving around in a circle with the radius R and making n revolutions per second, is able to read a magnetic tape recorded at the velocity v :

$$2\pi Rn = v.$$

R and n may be freely chosen as long as the above formula is respected.

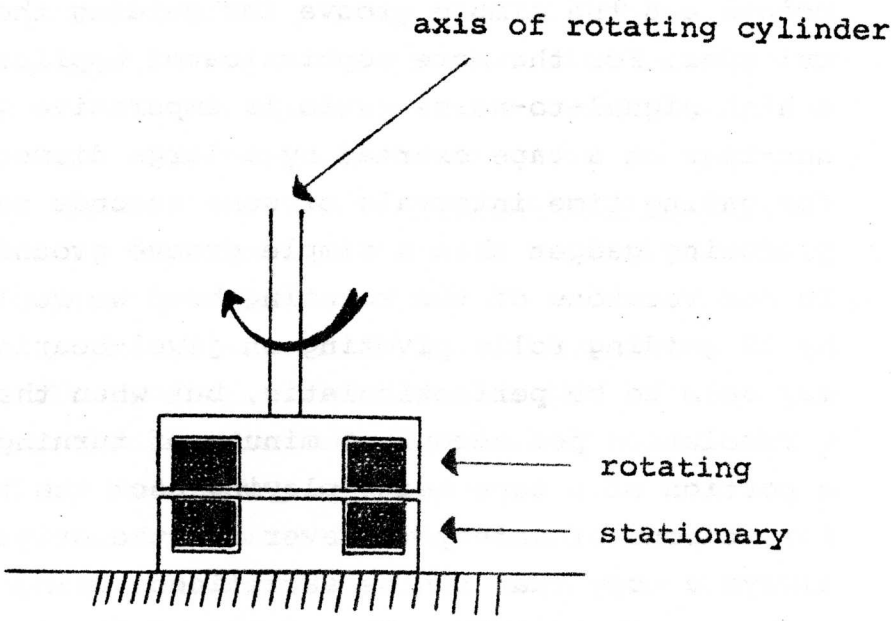
When the tape is completely looped around the cylinder, the head scans a time interval of almost

$$T = \frac{1}{n} \text{ sec during one revolution,}$$

so that the desired maximum value of T determines the value of n and consequently the value of the radius R when v is given, which usually is the case. As the head moves around and around the scanned signal is repeated again and again. It depends on the type of research one has in mind whether this repetition is really wanted at all, but quite often it is rather helpful.

By roughly positioning the loop around the cylinder (by hand or via a more sophisticated audio-controlled mechanical system) a certain time interval may be selected in which the acoustic phenomena that arouse our interest are embedded. With the present device a period of as long as two seconds may be lifted from the tape. In our institute, however, we always felt the need of exactly locating the beginning and the end of the 'gated' interval so that the width and the position of the gate were exactly known. For that purpose an extra switching device was needed for selecting a specified interval within the time span dictated by the loop. This brought us to grips with the physical nature of the switches involved and, already in an earlier phase of the development of the IFA-Gate, with the problems of feeding the, likewise rotating, preamplifier of the reproducing head with DC power and, last but not least, the headaches of connecting the audio-output of the preamplifier to the stationary outer world. After endlessly experimenting with metal sliding contacts of all sorts, carbon brushes and the like, we finally fell back on a modern version of the classical mercury contacts consisting of platinum electrodes dipped in mercury-filled gutters. This method was incorporated in the predecessor of the IFA-Gate 1973 and has been working successfully for almost seven years under punishing circumstances.

Though the contacts are still going strong, one never feels quite at ease with the use of mercury, however well protected the gutters may be: it is next to impossible to make the device completely 'student-proof'. Therefore we decided to abandon the mercury contacts in the new version of the IFA-Gate and to replace them by an inductive coupling in the form of a rotating transformer, as is schematically portrayed in figure 2.




F I G U R E 2

Schematic representation of one of the two rotating transformers of the IFA-Gate.

As a matter of fact two rotating transformers have been mechanically coupled to the axis driving the rotating head; one of them induces a 80,000 Hz voltage that is rectified in the rotating preamplifier into DC power, whereas the second transformer simply transmits the audio-voltage.

By an adequate choice of the output impedance of the preamplifier with a view to the magnetic properties of the transformer, the influence of mechanical asymmetries of the rotating parts on the output level has been drastically reduced: possible level variations completely disappear under the inevitable drop-outs of the used tape itself.

To my knowledge, the first mention of rotating reproducing heads is made in the well-known Review of Acoustical Patents in JASA (1951) Vol. 23, page 501: Richard Howland Ranger, February 6, 1951, 8 Claims (Cl. 179-100.2). It is called Magnetic Record Editing Apparatus, its chief aim then being to locate the exact position for a required cut. Obviously the reproducing quality was of no or little importance so that one could reconcile oneself with the very primitive contact points and the simple groove for guiding the tape around the cylinder. For the more sophisticated applications of 1973 a high signal-to-noise ratio is imperative whereas the wear-and-tear on a tape exerted by a large diameter cylinder needed for gating time intervals of some seconds needs a less friction producing gadget than a simple groove ground in the cylinder. In our versions of the rotating head we replaced the groove by 32 guiding rolls pivoting on jewel-bearings. This precaution may seem to be perfectionistic, but when the head makes ½ revolution per second, 1 minute of turning loose the head on a portion of a tape means playing back the tape 30 times. For reasons of safety we never use the original of a tape but always a copy that can be sacrificed. Using a copy is necessary anyhow as the gate has been designed for accepting low noise two track tape of which only one track is used, the second track being as 'empty' as possible. The reason for this extravagance is that the reproducing head has two reproducing gaps, the associated coil of one of which is used for hum-cancelling, in general a delicate problem when the coil that picks up the hum is moving through a magnetic field so that no stationary anti-hum coil can be applied.

We have always found the physical nature of the gate that selects a small portion of the 'exposed' loop to be a severe headache. Many gates are switching devices that behave in a very non-linear way at the beginning and the end of the selected interval. Also they may introduce clicks. Strictly speaking, we only need to bother about objective clicks, being extraneous signals injected by the gating device. But even objective clicks may be identified as such by comparing the gated signal with the 'full' signal.

The reason why we wanted to get rid of objective clicks is simply that we regarded removing them as a challenge. This brings us to a philosophy certainly not adhered to by all, not even by many: one should make a measuring apparatus around which fundamental research centres, as good as possible (of course within reasonable limits!), even exceeding accuracies presently wanted because one never knows how soon in this relentlessly developing scientific world problems will pop up that will make us sorry for having been so penny-wise-pound-foolish with accuracy when we still had some money to spare. When we sweep distortion and objective clicks together under the heading objective artefacts, we may oppose them to the subjective artefacts, which are the extra sensations we have to cope with while listening to the gated portion in stead of to the 'full' tape. Depending on the physical nature of the gating device, it is quite often difficult to distinguish between the two types of artefacts just mentioned: When the physical damage afflicted to the signal by the gating technique is more than somewhat, we may easily blame or, what is even worse, credit the auditory system for what one 'hears'. In this respect it is interesting to draw the attention to the gating technique employed in the IFA-Gate 1973 (and in its predecessor, at that): the signal generated by the reproducing head is multiplied in a very linear way by a square clock-signal (see figure 1): when the clock-signal equals 0 , the head signal is suppressed; during the time interval the clock-signal equals 1 , the head signal is freely admitted ($T_2$). When we tried out this system on, among other signals, fricatives like [s], the expected, and much debated, 'scar-phantom' [t] was so weak that we suspected our gate to be out of order. Careful physical examination (including, of course, inspection by oscillograph!), incorporating all types of signals, reassured us of the physical cleanliness of the multiplication method: the better one makes the gate, the less it gives rise to disturbing artefacts on which the easily-fooled 'ear phonetician' is inclined to base his phoneme-biased theories of hearing (just what he wants to hear).

In this context it is interesting to quote the wise-crack coined by Mr Emiel O. Kappner of our Institute: "A phonetician is somebody who does not believe his own ears". It is not without humour to add here, that I myself, after having listened to sounds of all natures for well over 30 years during which I developed a well-trained ear, am known if not notorious for my not too friendly attitude towards ear-phonetics. This is by no means a contradiction: the unconscious processing of physical cues by the auditory system of the listener 'in the street' is one thing, whereas the performance of a well-trained specialist who uses his ear consciously as, what he hopes to be, a measuring device is another thing.

In the IFA-Gate the speed of the motor driving the rotating head is kept constant by means of a magnetic toothed wheel generating an electrical voltage the frequency of which is judged by a discriminator. Two recording speeds are possible, to wit 9.5 and 19 cm/s, around which small, directly readable, fine adjustments within a range of plus or minus 5% can be made.

In order to facilitate the location of a certain passage on the tape, the IFA-Gate 1973 can be operated as a normal tape recorder: in that case the tape is read by a special stationary reproducing head, the rotating head being switched off after having come to a stand-still. The tape can be transported at a very high speed in both forward and backward directions. The apparatus is equipped with a special braking mechanism that clamps in when the electrically slowed tape is almost at rest. In that way the much dreaded breakage and other caprices of the tape are drastically prevented.

What shall we do with the segment the IFA-Gate extracts from the tape?

This is entirely up to the researcher. As the length of the segment can be adjusted between 2 msec and 2 sec a wide range of applications is put at his disposal; he may even isolate one vocal period of a vowel.

The gated segment may be fed into all kinds of apparatus, such as a computer interface, a spectrum analyser, a simple oscillograph or a memoscope, a digital delay line,

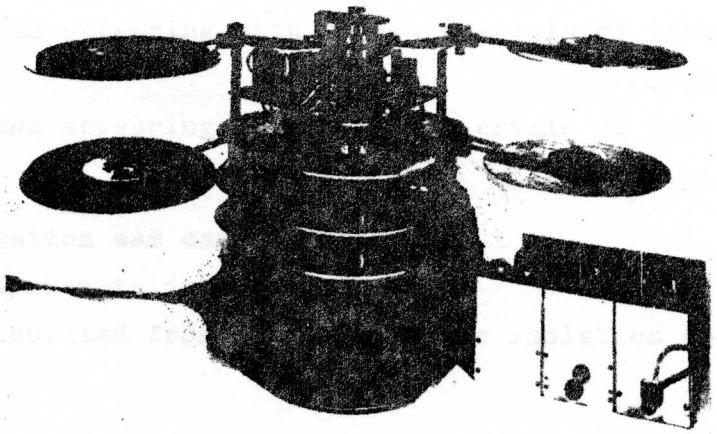

The IFA-Gate 1973 with cover removed.
The plug-in unit at the right shows thumb switches for setting the width and the location of the gated interval.
The plug-in unit at the left houses the output (based on peak value) amplifier with overload control.
The middle section contains all switches for the transport of the tape and the manipulation of the rotating head.

a transient recorder, a tape recorder (for the preparation of audio test tapes), a formant detector, a pitch detector and what have you.

The IFA-Gate has a built-in extra: instead of lifting a certain segment from the tape with the aim of presenting it to the researcher, it is possible to suppress the same segment so that the researcher is confronted with a recording with a special acoustic 'hole' in it.

This preliminary announcement of the IFA-Gate 1973 is not meant as a detailed specification; all precise data are at hand but as the gate is not commercially available we did not saddle ourselves with the making of a report pinpointing every detail.

The redesigned IFA-Gate 1973 has been built by the electronic technicians A.W. van Maanen, the mechanical technicians A.A. Heidbuurt and D.T. Jaasma, under the supervision of J.G. Blom, electrical engineer. The signal coupling by means of the rotating transformers, the electronic motor speed control and the electronic braking system have been developed by the electronic technician A.G. Wempe. I am very thankful to these men, who fulfilled many of my wishes even before I put them forward. I seize this opportunity to mention the enormous amount of preparatory spade work done by Mr F.W. Langhorst on predecessors of the IFA-Gate 1973.



F I G U R E 3

The first succesfull gate containing a rotating head designed by the author's speech group around 1955.

P R O C E E D I N G S  F R O M  T H E

I N S T I T U T E  O F  P H O N E T I C  S C I E N C E S

U N I V E R S I T Y  O F  A M S T E R D A M

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Amsterdam, 1973