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SST, A DEVICE TO TEST THE STABILITY OF THE SPOT-POSITION ON A MICROSPOT CRT

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ABSTRACT

This paper describes an instrument and test method to continuously measure the non-deflected spot position of a CRT over a long time.

After an introduction and description of the working principal some of the main components are briefly presented. The performance of the measuring system is described and some examples are presented that show how the instrument has been used.

CONTENTS

1. Introduction

One of the main components of the ERASME system is a 7" microspot CRT. The spot of the CRT is under computer control and can be moved in X and Y directions by two 16-bit D/A converters and a magnetic deflection system in order to make a raster scan over interesting areas of the projected film image. The least count on the CRT is about 2µm, and the short term reproducibility of individual digitizings from well-defined objects, for instance a line on a calibration grid, have a standard deviation $\sigma < 1$ least count.

The spot diameter can be kept to $\approx$15µm and the intensity distribution of the spot is kept symmetric over the whole area of the screen by using dynamic correction. That means that correction currents are fed through the focus and astigmatism coils as a function of spot position on the screen.

Before a CRT is put into operation it is carefully tested. Parameters checked are: spot diameter, screen noise, light output-versus beam current, the non-deflected position of the spot, etc. Tests have shown that on some CRT's the position of the non-deflected spot is not constant but can jump to another position or drift slowly. These movements can be several tens of microns and occur intermittently so are therefore difficult to detect. This is of course serious for the precision of the measurements that require the short term stability (20 minutes) to be better than $\approx$1 least count, and the long term drift (24 hours) to be $\lesssim$ 50µm in order to avoid too frequent recalibrations. It has therefore been found useful to have an instrument which measures the non-deflected spot position continuously with high precision over long periods. One is then able to find out if the tube is stable before it is put into operation in a measuring machine. This is important as it can be difficult in a fully assembled system to judge if an instability is caused by the CRT itself, as it can also have other sources; D/A converters, deflection drivers, HT-power supplies, etc.

The instrument has also been used for other tests when a precise measurement of the spot position is necessary. For instance, measurement of deflection coil hysteresis and settling time, influence of temperature changes of the deflection coil etc.

In the following an instrument and test method are described by which the non-deflected spot position can be measured with at least the same precision as a completed S/M unit and that requires only a partial tuning of the CRT.

2. Working Principle

The CRT is mounted on an optical bench and the deflection, focus, and astigmatism coils are mounted and tuned to get a well-focussed, and astigmatism free spot in the centre of the screen. A microspot analyzer is placed on the bench and adjusted so that the image of the spot falls in the image plane of the analyzer. (Fig. 1).

A pattern with 4 transparent slits on dark background (Fig. 2) is placed in the image plane of the microspot analyzer and adjusted so that the spot falls in the middle of the square 'box'.

The spot is now deflected in a well-defined path over the pattern. First a sweep in the X-direction with no deflection in Y and then opposite, thus forming a small cross with a size of about 250μm in the middle of the screen.

The deflection currents are sensed by a zero-crossing detector, and when the currents go through zero count pulses from an oscillator are fed to a scaler. When the spot passes the narrow slit a video pulse comes from the PM-tube in the analyzer. The mid-point at half height of this video pulse stops the count pulses to the scale and causes the content to be transfered to an X- or Y- register depending on the direction of the sweep. Both of these registers are connected to D/A converters which are in turn connected to some kind of analogue recording device. All movements inside the box will thus be continuously sampled.

3. Some Design Characteristics

The instrument is quite flexible, and can be tuned in different ways depending on which kind of measurement is to be made. In the following section some of these parameters will be discussed.

The scan speed is normally set to about 0.5μm/μs. That is 10 times slower than the speed during normal measurement, but has been chosen so low to get a favourable signal to noise ratio. This is especially important when the tube is biased to give low light output. The optical magnification is selected in the range 4-12 times depending on which precision is wanted and how much spot movement is expected. With a magnification of 5x the size of the box on the screen is 250 x 250 μm, and the width of the slits are 10μm. With a clock frequency of 0.5Mhz, which in fact can be varied between 0.25 and 1Mhz, one can get a least count of 1μm corresponding to 0.4 least counts on an S/M unit. With this setting, movements up to ± 100μm in X and Y can be recorded.

As mentioned before, only a simple adjustment of the CRT is necessary. It is enough to have a spot with a diameter $\lesssim$ 25μm with a symmetric intensity distribution. If the spot has an unsymmetric shape a drift in the focus current, or a change of amplitude of the video signal, could give an error in the position because the midpoint at half height of the video signal has to be detected.

The precision of the system, to be presented later, requires that the mechanical arrangement is stable and free from vibrations. It is also necessary to keep the temperature constant in the test room.

4. Main Components (Fig. 3)

4.1 Linear sweep

The linear sweep is generated by an internal generator where frequency, DC-offset, and amplitude can be tuned within certain limits. It is enough to keep the frequency and amplitude within 0.5 - 1% during the measuring period. A small drift in the DC-offset has no importance because the zero crossing is detected.

As a further point, it should be mentioned that the deflection may be synchronized with the mains. This can be useful in an electrically noisy environment.

4.2 Deflection

The signal from the sweep generator is split by a FET-switching circuit into X- and Y- sweeps. The signal is then fed to current amplifiers which are connected to one of the two push-pull coils for X or Y. The deflection currents are directly sensed by comparators which detect when the currents go through zero.

4.3 Scaler, Registers

The 8-bit scaler with its control logic receives count pulses from the oscillator which are enabled into the scaler at Z-crossing. At the leading edge of the video pulse the oscillator frequency is reduced by a factor of 2, and at the trailing edge the scaler is stopped and the contents, which now correspond to the distance from Z- crossing to the midpoint of the video pulse, is transferred to the registers. The D/A converters have amplifiers in which gain and offset can be tuned to levels suitable for the recording device. The control logics also generate an internal reference video signal that is used for debugging, and to measure the noise and drift generated by the instrument itself.

4.4 Fast Jump Detection

If the spot is displaced only for a short time ($\lesssim$100ms) the recording instrument can normally not respond fast enough. The outputs are therefore connected to a discriminating circuit with a differentiating element ($T \approx 10$ms) on the input. This circuit can be tuned to count up a scaler only for jumps larger than a certain presetable number of microns. The scaler will thus contain how many times the spot has made fast jumps during the test period.

4.5 Blanking Control

The instrument also controls the spot blanking. The CRT can either be continuously unblanked, or unblanked only during short periods (10 or 50 ms). In the later case the frequency can be changed over a wide range. One can in this way change the duty cycle between 100 and 0.1% in order to simulate all normal working conditions.

5. Results

Fig. 4a shows an output when the internally generated signal is used. 1 least count corresponds here to 1 μm. From this we can see that σ (short time) is $\lesssim$0.3μm.

Fig. 4b shows the same case, but a real video pulse is used. σ is now $\lesssim$0.5μm.

The drift for the reference signal has been recorded over a long period. In Fig. 5 we can see that the drift generated by the instrument itself is 1 μm.

6. Applications

Fig.6 show some typical measurements from CRTs.

Fig. 6a and 6b demonstrate two bad tubes. 6a is a tube where the spot drift is quite small but the spot occasionally jumps back and forth. 6b has no jumps but the spot drifts slowly ($\approx 50\mu m$/8 hours).

Fig. 6c shows a good tube with no jumps and the drift is only $\approx 6\mu m$ over 10 hours.

In reference 4 the specification of short term and long term stability of the ERASME measuring system is discussed in detail.

Deliberately offsets were introduced to the zero position and the influence on the calibration results was studied.

Fig. 9 demonstrates a measurement of spot movements which, after some confusion, was found to be caused by the stray field from the synchrocyclotron at CERN which is situated about 75m away from the ERASME system. It turned out that the stray field of about ≈ 70m Gauss could penetrate double μ-metal screening and displace the spot $\approx 10\mu m$. This called for an improvement of the magnetic screening of the CRT.

7. Figure Captions, References

Fig. 1.	Test arrangements
Fig. 2.	Measuring principal
Fig. 3.	Block diagram
Figs.4a, b,	Short time precision
Fig. 5.	Long time stability of the instrument
Figs.6a,b,c.	Drift measurements from different tubes
Fig. 7	Disturbance from external magnetic field
Figs.8a,b.	Photos of the equipment

Acknowledgements

The authors would like to thank Mr. Duran and Mr. Willmott who assisted in the debugging of the final version of the instrument.

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2. Description and Status Report of the ERASME System; CERN/D.Ph. II/INSTR. 74-5 (DD/74-15). Oxford Conference on Computer Scanning, April 2-5, 1974.

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4. H. Anders, R.E.S. Berglund and J. Orpesa: CRTs for ERASME, a detailed review. CERN DD 76/7/EF/INSTR. 76-2. Conference on Computer Assisted Scanning, Padova, April 1976.

5. Ferranti: Microspot Analyzer MA100.

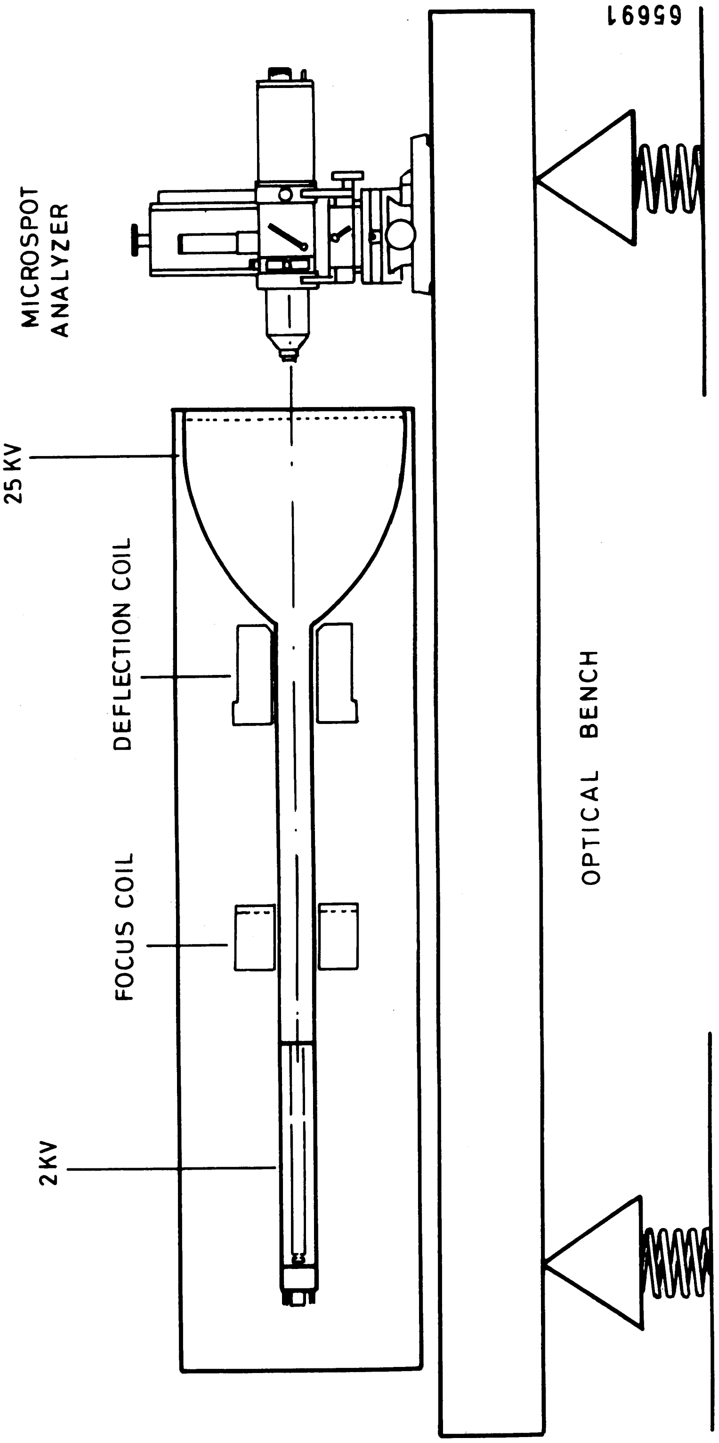

MICROSPOT ANALYZER
25 KV
DEFLECTION COIL
FOCUS COIL
2 KV
OPTICAL BENCH
65691

Fig. 1

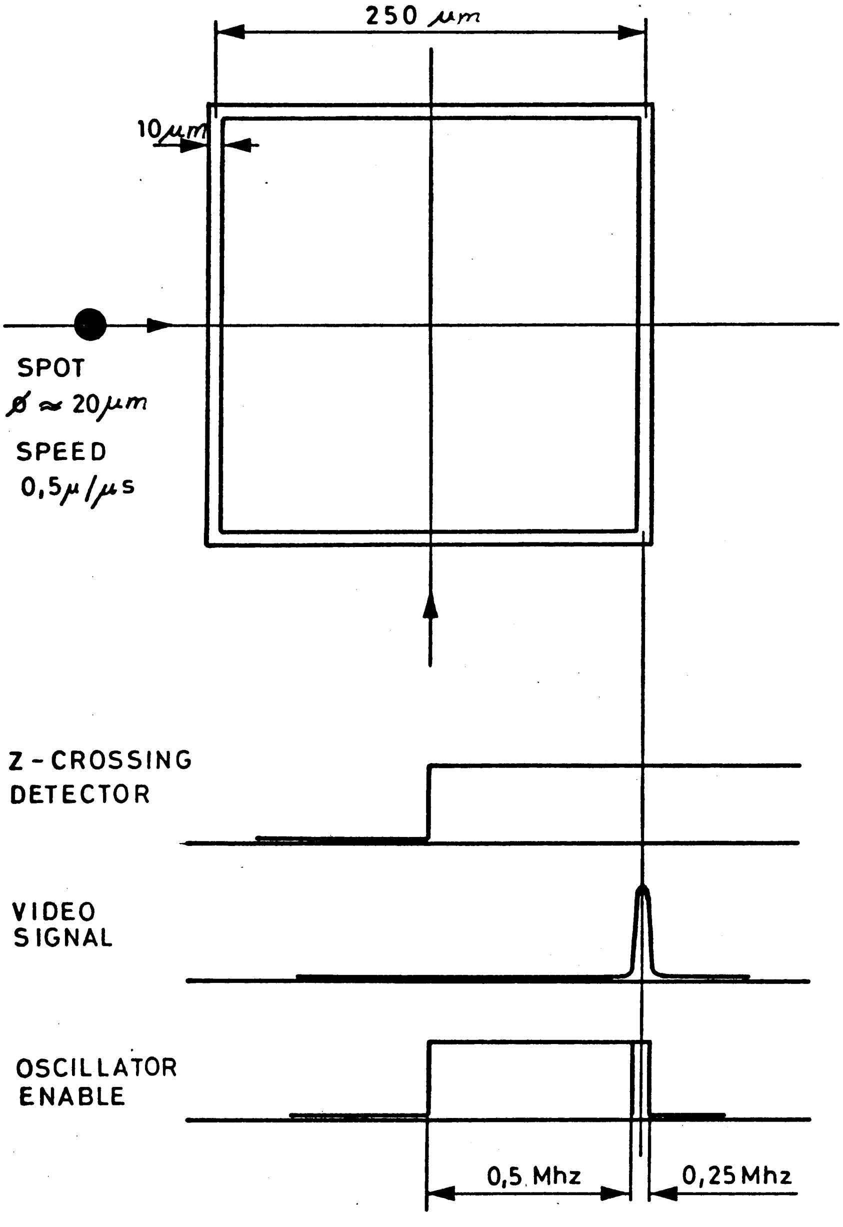

250 µm
10 µm
SPOT
ø ≈ 20µm
SPEED
0,5µ/µs
Z-CROSSING
DETECTOR
VIDEO
SIGNAL
OSCILLATOR
ENABLE
0,5 Mhz
0,25 Mhz

Fig. 2

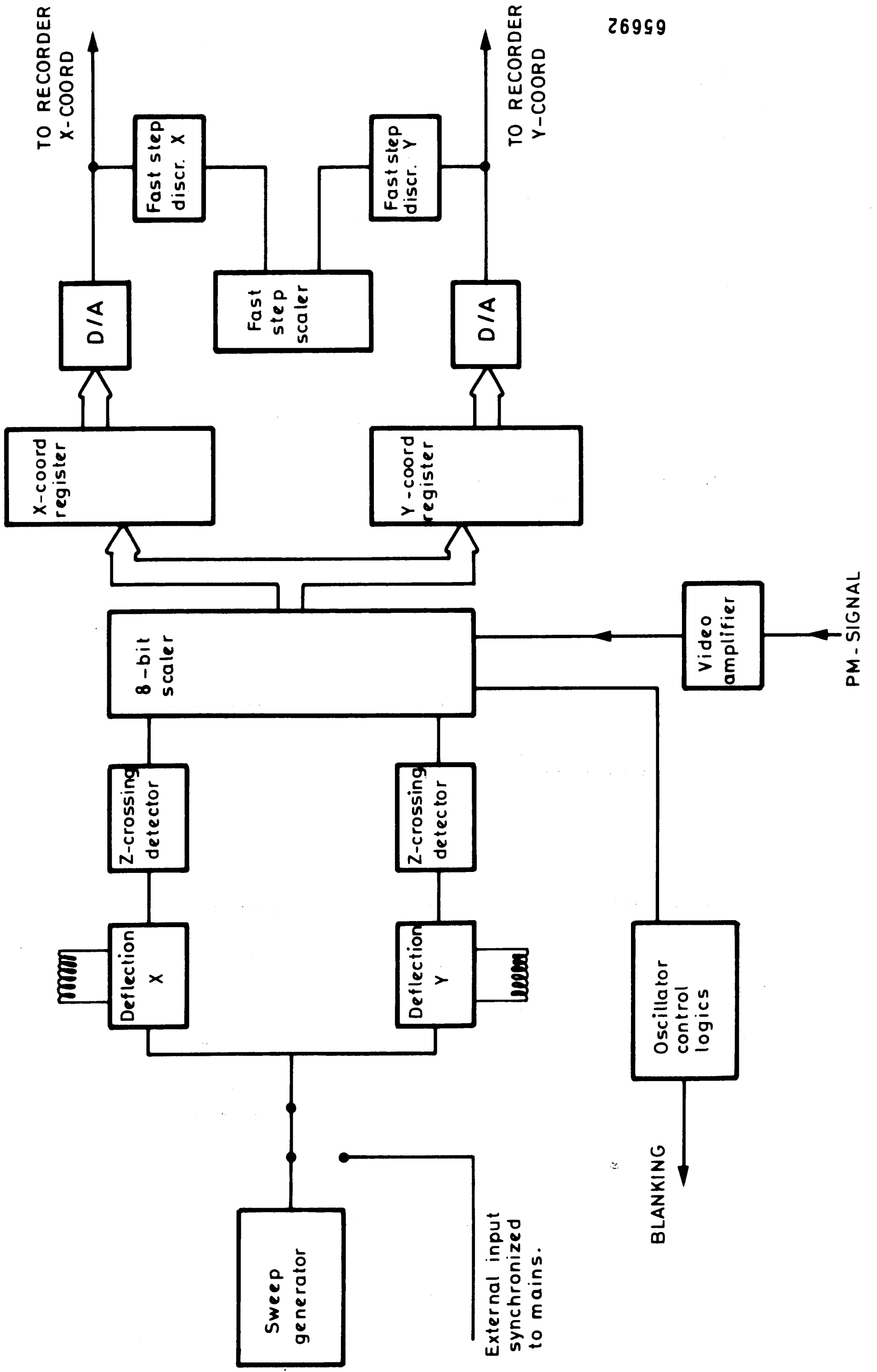

TO RECORDER X-COORD
TO RECORDER Y-COORD
65692
Fast step discr. X
Fast step discr. Y
Fast step scaler
D/A
D/A
X-coord register
Y-coord register
8-bit scaler
Video amplifier
PM-SIGNAL
Z-crossing detector
Z-crossing detector
Deflection X
Deflection Y
Oscillator control logics
BLANKING
Sweep generator
External input synchronized to mains.

Fig. 3

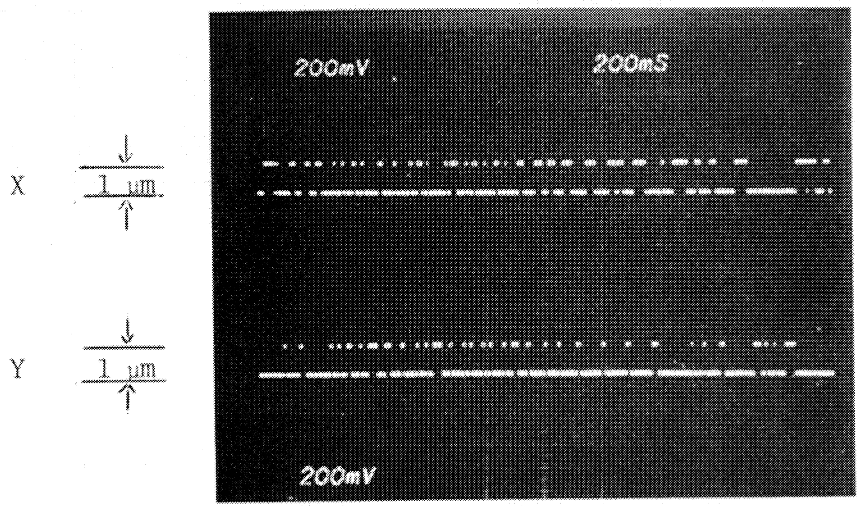


Fig. 4a

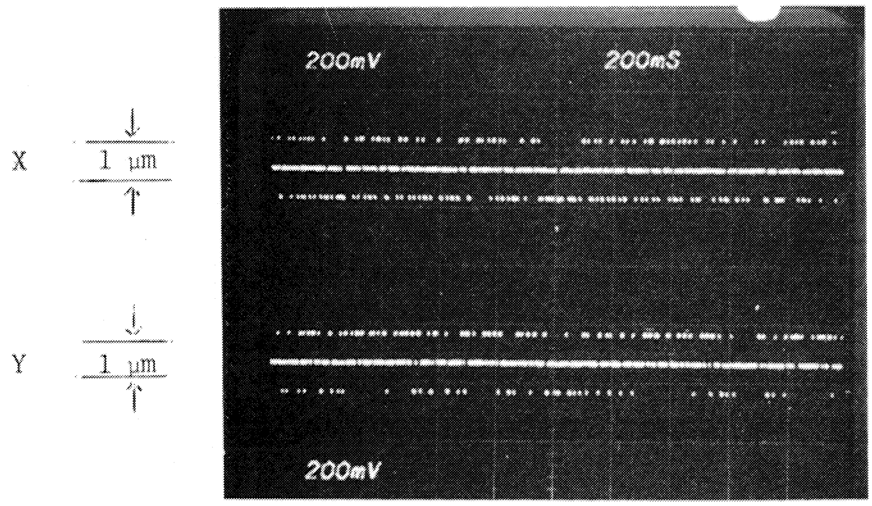


Fig. 4b

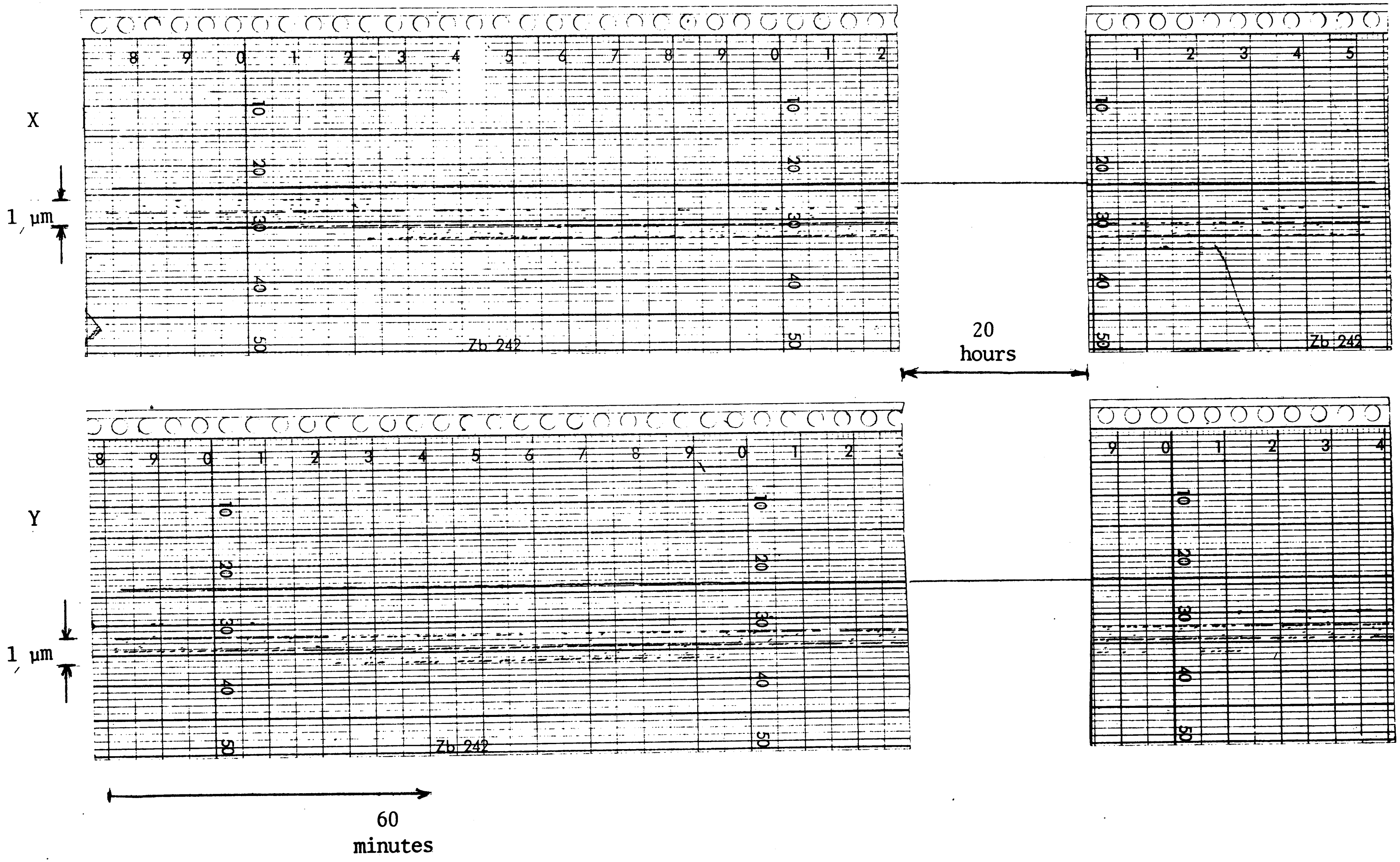

X
Y
1 µm
1 µm
20 hours
60 minutes
Zb 242
Zb 242
Zb 242
8
9
0
1
2
3
4
5
6
7
10
20
30
40
50

Fig. 5

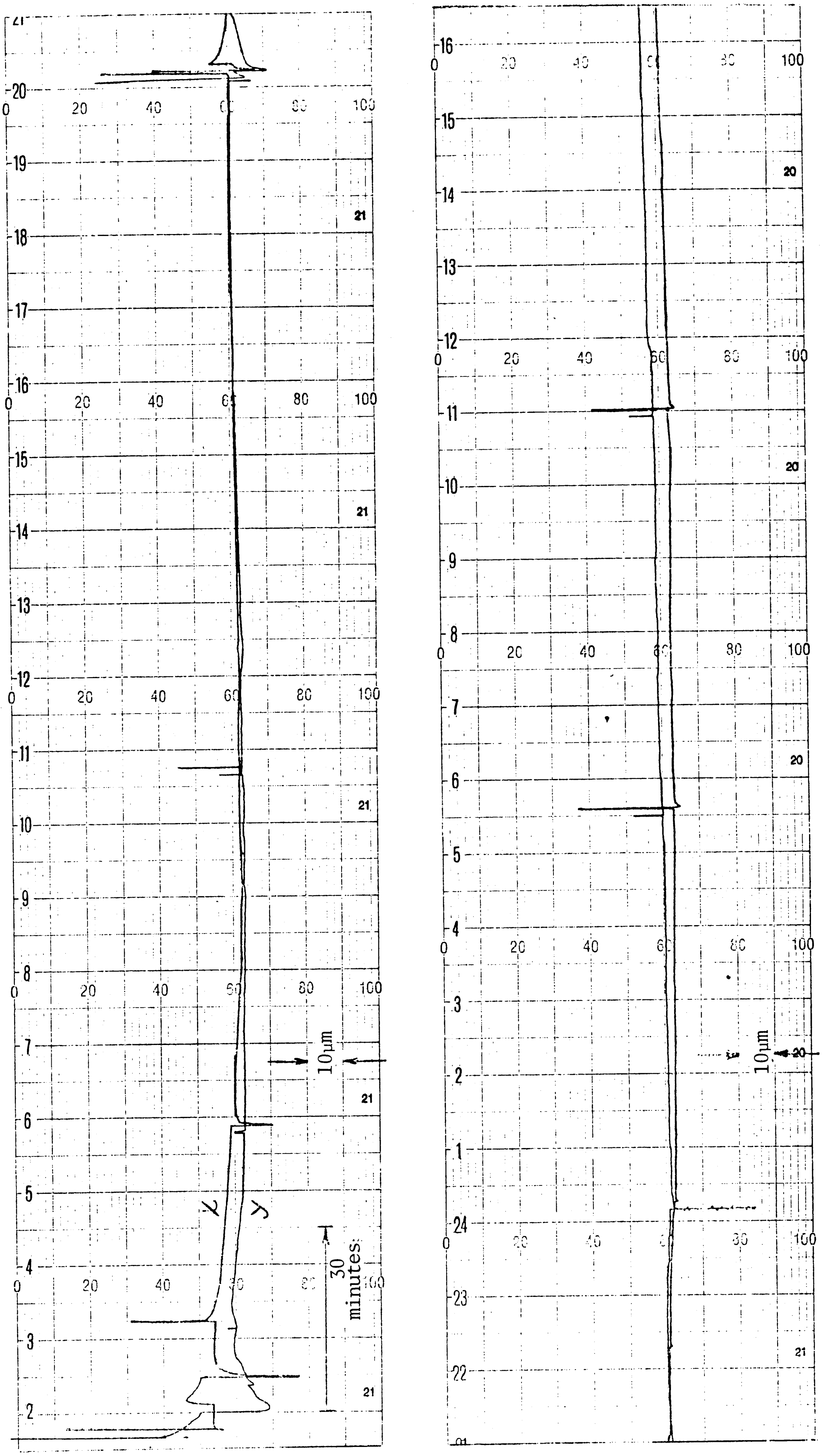
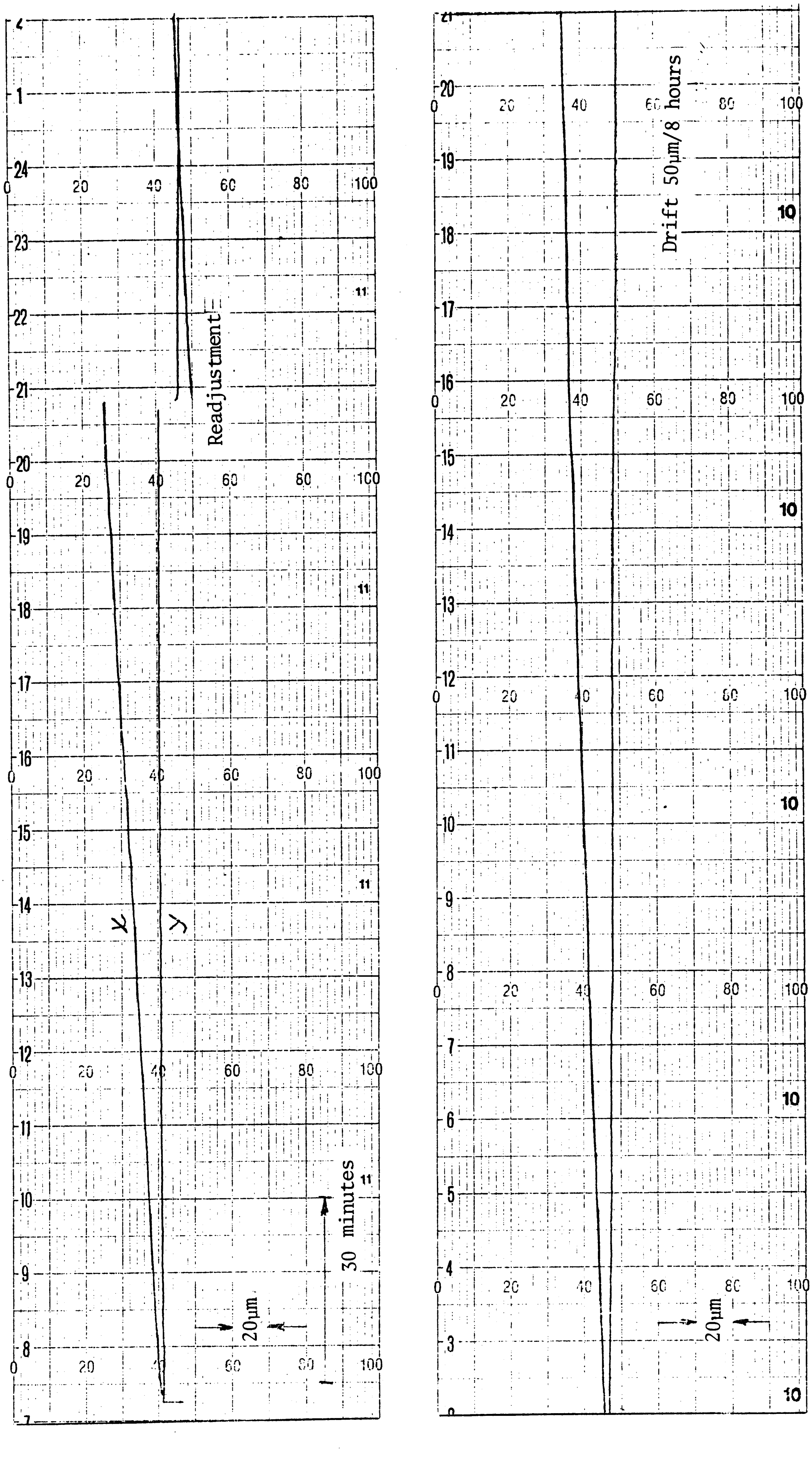


Fig. 6a


Readjustment
x
y
30 minutes
20µm
Drift 50µm/8 hours
20µm
0
20
40
60
80
100
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
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18
19
20
21
22
23
24

Fig. 6b

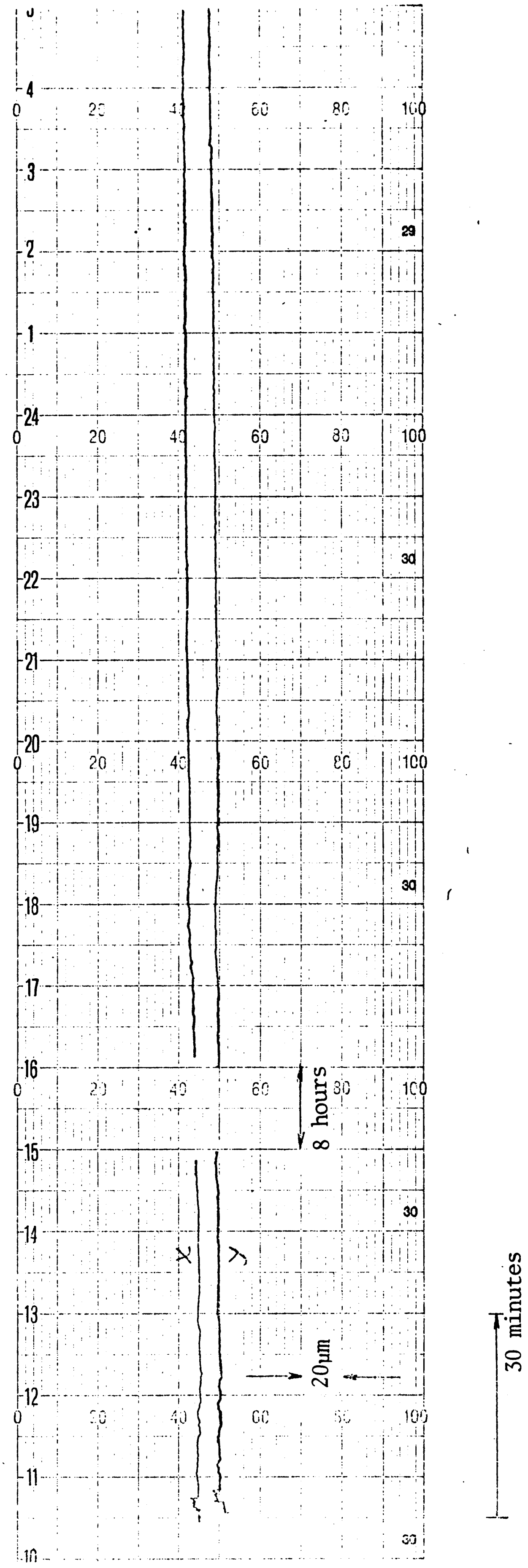
4
3
2
1
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
0
20
40
60
80
100
29
30
X
Y
8 hours
20µm
30 minutes

Fig. 6c

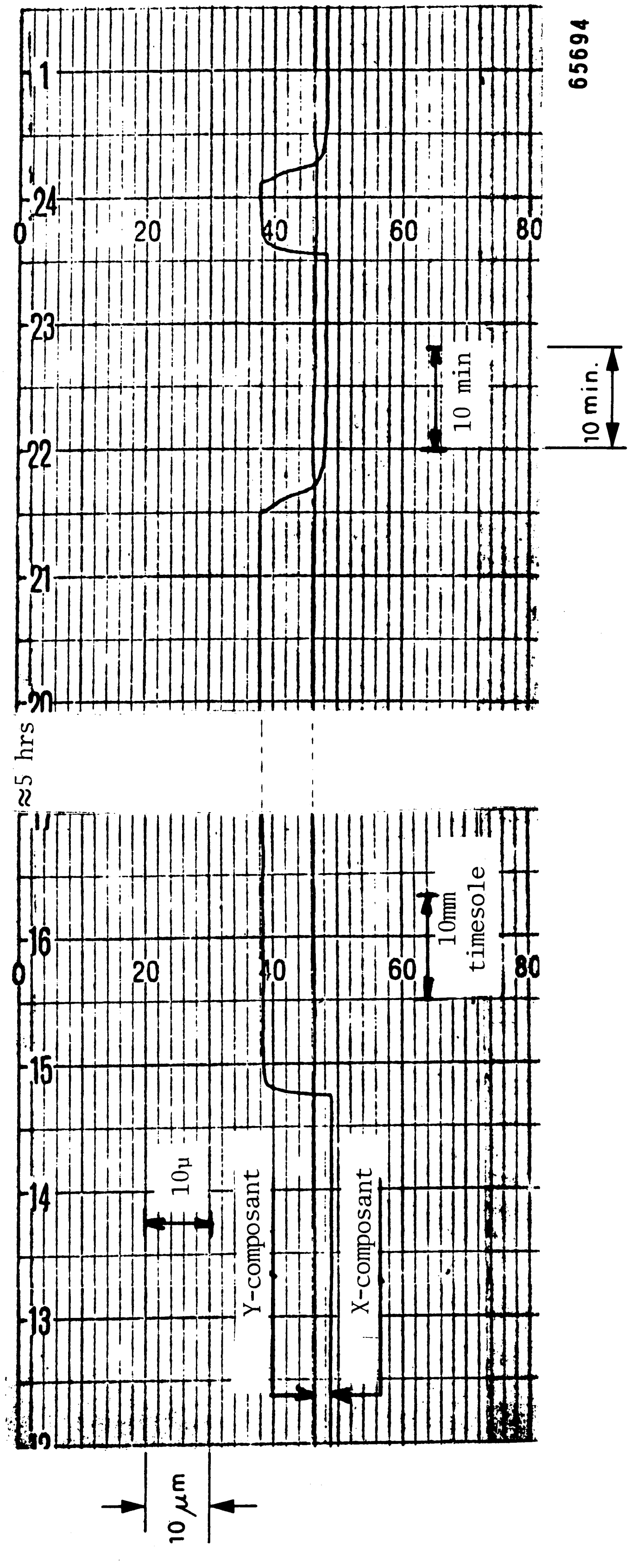
65694
1
24
23
22
21
20
0
20
40
60
80
10 min
10 min.
≈5 hrs
17
16
15
14
13
12
10mm timesole
10μ
Y-composant
X-composant
10 μm

Fig. 7

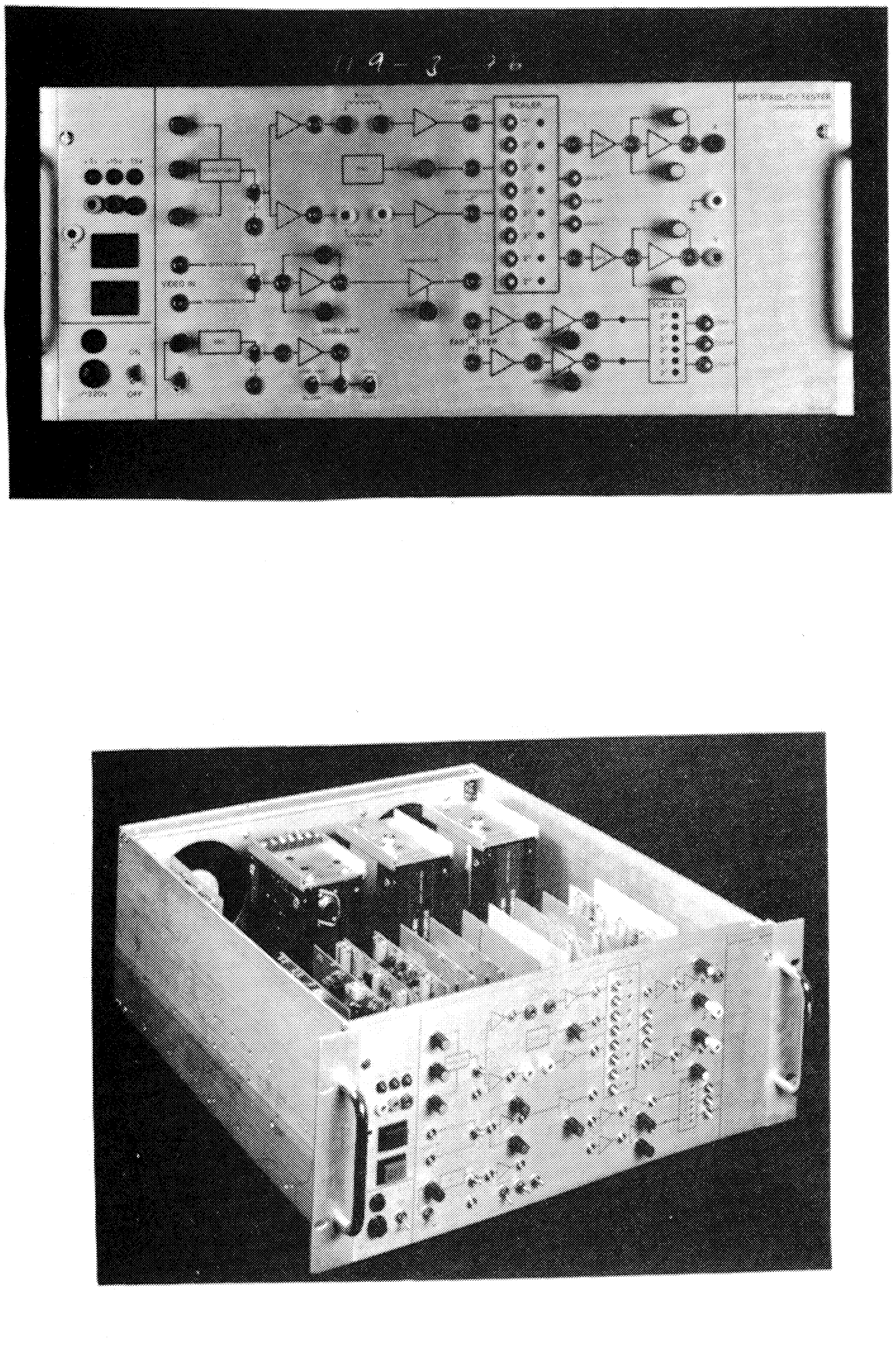

Fig. 8a

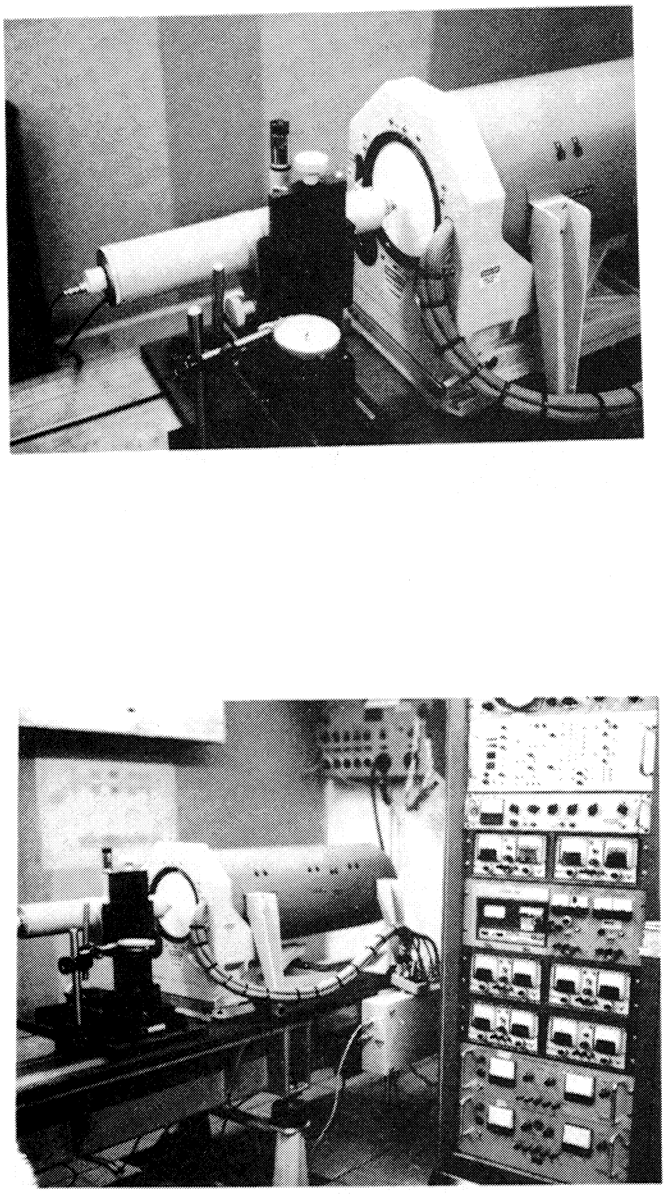

Fig. 8b