Reproducible Spark Generation: Design and Programming Work

Diploma paper

by

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CONTENTS

1. COMBUSTION STUDIES WITH LASER METHODS

The Department of Atomic Physics, Lund Institute of Technology runs a project with the purpose to study what actually happens in the initial stages of a combustion. Especially combustions started by a spark are of interest. The studies are concentrated on the initial stages of the combustion. These are very short, in the nanosecond region, and can be of crucial importance for the subsequent combustion.

The project concentrates on recently developed laser methods such as laser-spectroscopy, laser-induced flourescence, Raman spectroscopy and CARS spectroscopy (1). Raman and CARS spectroscopy are used for studying initial stages of reactions. Laser methods also allow non-contact measurements.

The long-term aim with these studies is to obtain an increased understanding of combustion processes which may lead to improved combustion engines.

This work has dealt with some devices used in the project. Electrical and mechanical design work was made on a spark device. This device, fed with 5 kV DC, gives reproducible sparks between two electrodes. The gas surrounding the electrodes and its pressure can be freely chosen.

A multi-channel analyzer with a built-in microcomputer used for spectrum analysis was calibrated. For this calibration, a PDP-11 computer was used, for which some computer programs were written.

Finally, a double entrance slit including holder for a monochromator attached to the multi-channel analyzer was designed. The double slit was cut out from a plastic plate with a CO_2 laser. With the double slit two different spectra with slightly differing wavelengths can be examined at the same time.

2. ELECTRICAL AND MECHANICAL DESIGN WORK

2.1 INTRODUCTION

In this combustion research project, much interest is focused on spark ignition of gas mixtures. Especially, the first stages of the ignition are of interest, for which measuring methods with a time resolution of a few nanoseconds are valuable. The CARS method seems to be useful in this context.

Many factors affect an electric discharge between two electrodes in a gas. The most important are:
- The voltage and current.
- The electric gap, the electrode shape and their composition.
- The gas pressure and composition.

Sparks in gases may be subject to fluctuations in space and time. Especially the initial stages of the discharge and the time delay between the voltage and current pulses may vary much. These fluctuations are mainly caused by the number density of free charges in the gas and by the electrode surface shape and condition. The number density of free charges varies randomly in space and time due to radioactivity of cosmic or other origin.

To reduce the time fluctuations to the nanosecond region, an electronic device for voltage supply to the spark gap was made as described in the next chapter. The initial space fluctuations of the spark was succesfully reduced by using a pre-ionized spark gap described in chapter 2.3. Chapter 2.4 describes the enclosure box containing the electrodes and the gas mixture. The chamber offers optical access to the spark gap and possibilities to change the electrode distance and the gas pressure.

2.2 ELECTRICAL DESIGN.VOLTAGE AND CURRENT MEASUREMENTS.

The designed circuit is developed from an earlier circuit used in a preliminary study (2). Lasers with a very constant time delay between trigger pulse and laser pulse are available. Such lasers allow synchronizing in the nanosecond region.

The time delay of the spark discharge current can be reduced to the nanosecond region by letting the applied voltage rise to several times the static break-down voltage in the same time scale. The designed voltage supply, figure 2.1, is able to give these voltage pulses.

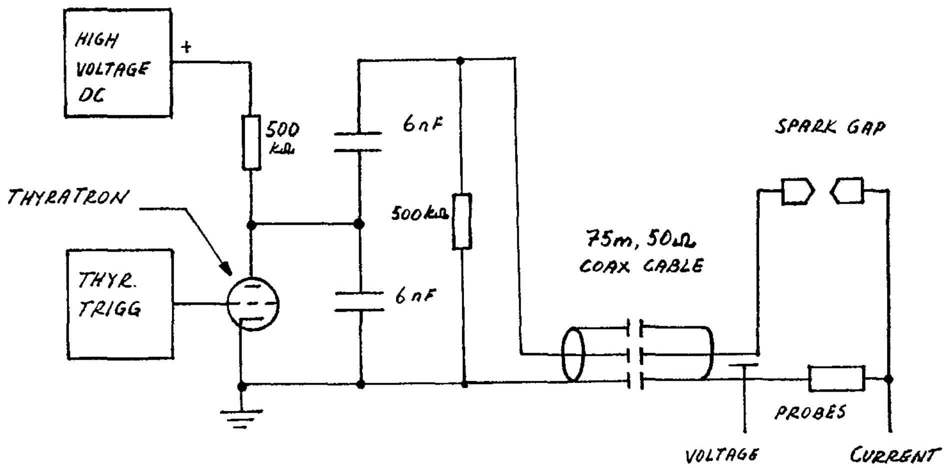


Figure 2.1: Electric supply

The thyratron acts as an inductive diode for a short time when a trigg pulse reaches it. The lower capacitor discharges through the thyratron and obtains a changed voltage polarity. Both capacitors then discharge through the 50 ohm coaxial cable, causing a voltage wave propagating at a speed of about 0.2 m/ns. Reflected pulses will appear at intervals of 2*75m/(2*exp8m/s)= 750 ns.

In the initial experiments, electrodes of stainless steel, with shape and dimensions given in figure 2.2, were used. A low-pressure mercury lamp giving 254 nm radiation was used to illuminate the electrode surfaces. The lamp lowered the breakdown voltage by releasing electrons from the electrode surfaces.

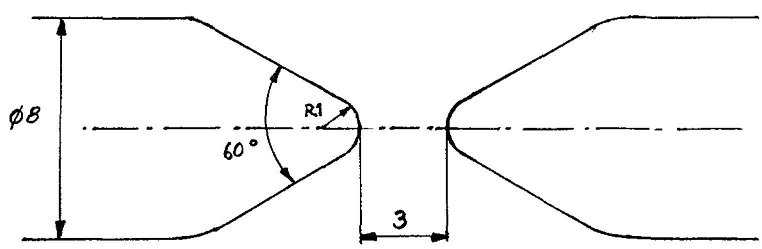


Figure 2.2: Electrodes

Voltage measurements were performed with a capacitive voltage divider made from a 100*38 mm piece of elastic polyester laminate of dielectric thickness 0.05 mm. Both sides of the dielectric were covered with copper coating. This piece was formed to a cylinder and placed arround the outer end of the cathode. One side was connected to ground and the other to a 125 ohm cable connected to a 0.3 ns rise time oscilloscope. As the foil capacitance was 2.65 nF, the time constant has the value Z*C = 125*2.65 = 330 ns. This must be corrected for in accurate measurements.

The current was measured by a specially designed probe, described in chapter 2.5.

The high-voltage supply was adjusted to 8 kV and the enclosure containing the electrodes was filled with nitrogen of 0.65 bar pressure. The deduced voltage and current pulses are shown in figure 2.3. Some further current pulses appeared at intervals of 0.75 microseconds, but no further voltage pulses appeared. This indicates that the spark resistance remained low for several microseconds.

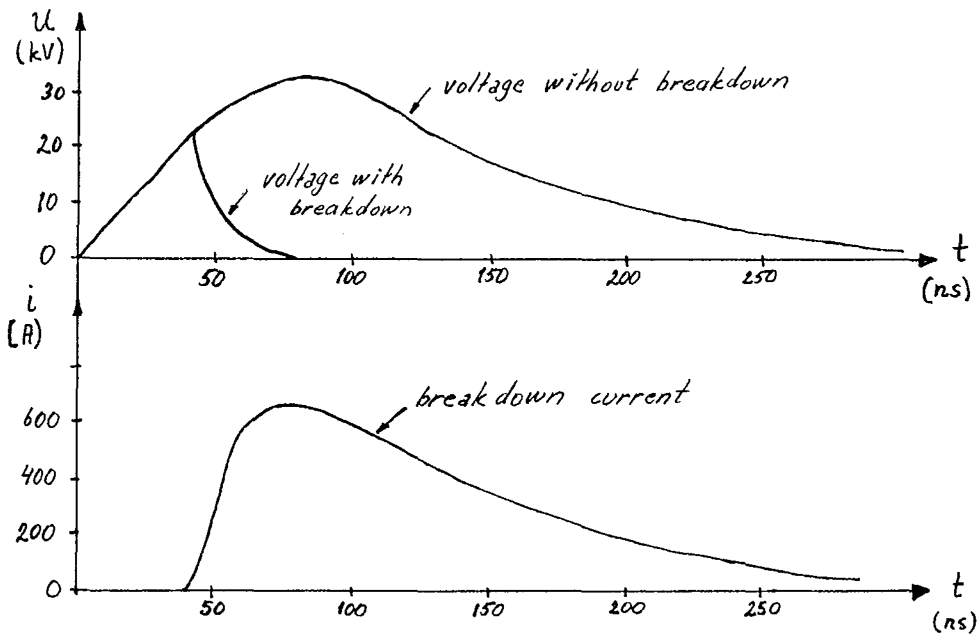


Figure 2.3: Voltage and current pulses

2.3 PRE-IONIZED SPARK GAP

The electrodes in figure 2.2 were used for the initial experiments. The electrical design described previously gives the desired voltage and current pulses. However, the sparks between the electrodes fluctuated much in space, up to 1 mm or sometimes even more. Some sparks were S-formed.

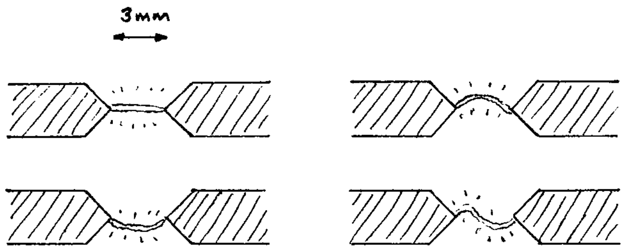


Figure 2.4: Possible and usual spark paths.

Some tests were also made with spherical and plane electrodes. These electrodes showed the same spatial fluctuations between the electrodes but they also showed fluctuations in the starting and terminal points on the electrode surfaces. Plane or spherical electrodes electrodes with a homogeneous discharge between the electrodes would be preferable, but it is difficult to avoid channel formation.

Many attempts were made to reduce the spatial fluctuations of the sparks. Totally, four different electrode shapes were tested, see figure 2.5. Electrodes number 1 reduced the the starting and terminal point fluctuations but did not affect the spatial fluctuations. Tests with varying high-voltage adjustments were also made, but with no significant improvements.

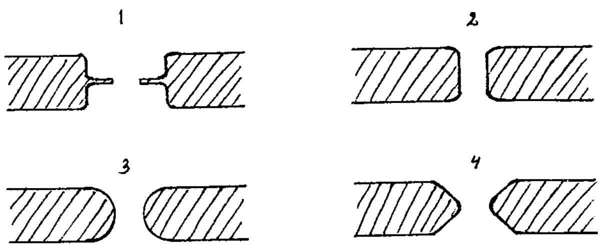


Figure 2.5: Tested electrode shapes

In CARS and BOXCARS experiments, laser beams are focused from different directions to the point of study, in our case a part of the spark. With spark fluctuations in the millimetre range, only tew measurements would be correct and many of them would give no result at all. The spark has to be stabilized in some way.

The spark space fluctuations are mainly caused by cosmic radiation. This radiation randomly ionizes atoms and molecules in the spark gap (and elsewhere). The spark travels the path of least resistance between the electrodes. An ionized area works as a guide for the spark. Thus, if we could create a thin and straight ionized path between the electrodes, this might solve the problem. These are the thoughts behind the idea with the pre-ionized spark gap proposed by Stig Borgström. To obtain a pre-ionized spark gap a special electrode was designed.

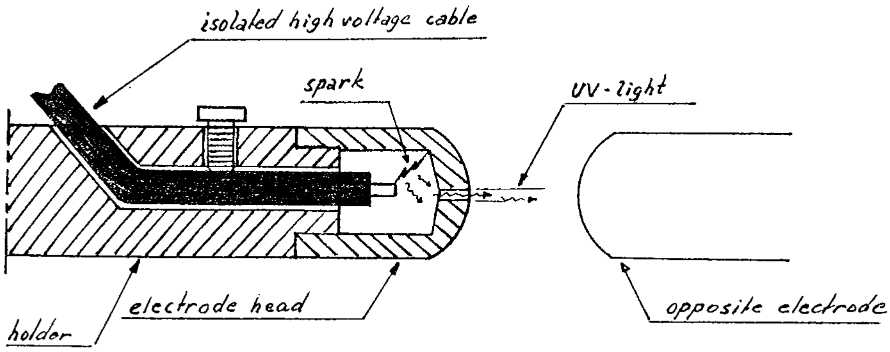


Figure 2.6: Pre-ionized spark gap

The special electrode consits of an electrode holder, an electrode head, a screw and an isolated high-voltage cable. The high voltage cable is 50 metres long and conected to the electric supply in the same way as the 75 metre cable feeding the spark gap. As the 50 metres cable is 25 metres shorter, a voltage pulse is obtained at the end of the cable inside the electrode head about 125 ns before the other voltage pulse reaches the spark gap. As the voltage pulse reaches the end of the high-voltage cable, a spark develops between the end of the cable and the electrode head. Ultraviolet light is created and some of it can pass through the 1 mm diameter hole out to the main spark gap. A thin channel of ultraviolet light is formed in the spark gap, causing ionization of some molecules. A short time later a spark strikes in the gap. This spark is guided by the ionized molecules in the thin channel and travels straight through the gap.

By looking at the sparks created this way it is apparent that almost all bent and S-formed sparks have disappeared. The sparks now follow a straight path between the electrodes. About one spark out of 50 follows an erratic path.

A polaroid camera was used to make a quantitative analysis of the advantage with the new electrodes. Fifty consecutive sparks were exposed on the same photograph. This was done both for the usual spherical electrodes and for the electrodes with the pre-ionized spark gap. The high-voltage and the gap width were adjusted to the same values in both cases. On both photographs the fifty sparks were seen as a white line. The white line was 1 mm broad for the new electrodes and 2 mm for the old spherical ones. The white line was also more distinct for the new electrodes, indicating straight spark paths.

The pre-ionized spark gap also admitted the high-voltage to be lowered from 8 kV to 5 kV. The voltage and current behaviour was similar to that described previously but more reproducible.

2.4 THE SPARK CHAMBER

This chapter gives a short description of the spark chamber used. The chamber serves to hold the electrodes centered on a chosen distance from each other and to enclose the gas. The chamber diameter is 110 mm, its height 130 mm and its wall thickness 8 mm. The mechanical design allows the pressure to be lowered to at least 10exp-5 bar obtainable with a mechanical vacuum pump. About 10 bar is the highest allowable pressure.

The box has two electrical feed-throughs opposing each other and three windows for optical access. The low voltage electrode can be adjusted about 3 mm in order to vary the electrode distance. The voltage and current probes are placed at the end of the electrodes.

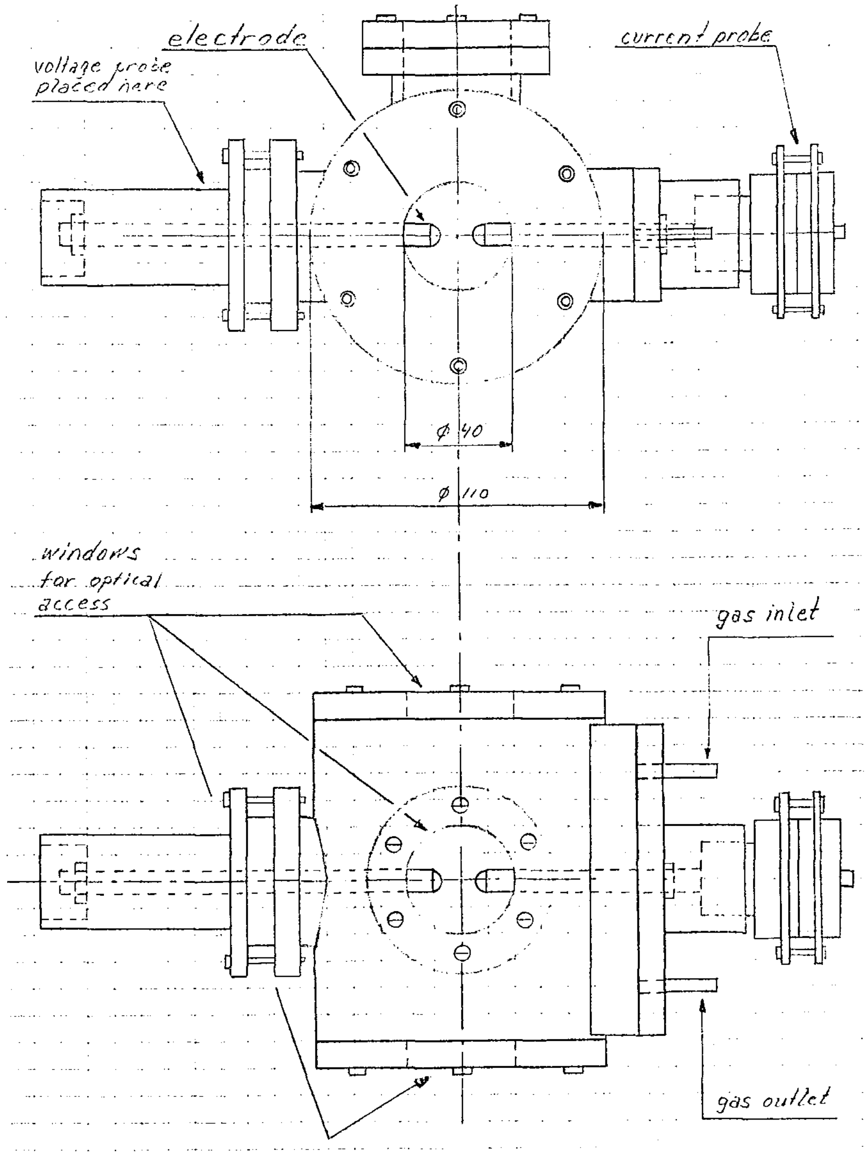


Figure 2.7: Spark chamber

2.5 CURRENT PROBE

An unknown current can be measured by letting it pass through a known resistance and observing the voltage drop. In the present project some points have to be observed. The current to be measured has nanosecond variations. Therefore the inductance must be low.

The inductance is minimized by using a circular shape for the resistance element.

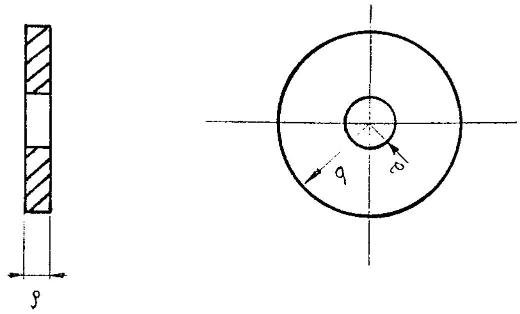


Figure 2.8: Resistance element made from Kanthal foil

The resistance R can be calculated with the formula

$$R = \frac{\rho}{2\Pi\delta} \ln \frac{b}{a}$$

where ρ is the resistivity of the material. For the chosen values ρ = 1.40   mm2/m (Kanthal), δ = 0.11 mm, b = 22.5 mm, a = 2.5 mm, R becomes 4.45 m .

In order to avoid contact contact resistances affecting the measured voltage drop, the voltage measurement contacts have to be separated from the current contacts. This demand is fulfilled by the constructed current probe shown in figure 2.9. Complete drawings are shown in Appendix A.

The resistance was measured for direct currents up to 5A and for frequencies up to 1 Mhz.

Table 2.1: Resistance as a function of current

I (A)	R (m)
0.50	4.06
1.00	4.05
1.50	4.05
2.01	4.10
2.99	4.07
5.01	4.06

Table 2.2: Resistance as a function of frequency

f (kHz)	R (m)
0.1	4.5
1.0	4.4
10	4.4
100	4.4
1000	4.4

The measured resistances in table 2.1 differ from those in table 2.2. This depends on the top contact, which is held by a nut. If the nut has been screwed of between different experiments the probe resistance may differ, which is caused by sligthly differing geometry and contact pressure. Therefore, an accurate experiment with the probe involved must be preceeded by a probe calibration. If the nut is screwed off, the probe can be fitted directly to the chamber described in chapter 2.4.

According to table 2.1, the resistance does not vary significantly with the currents used. Since the resistance change with frequency also can be neglected up to 1 MHz, the probe inductance is very small. However, the skin effect will make very high-frequency measurements inaccurate since the skin depth equals the actual foil thickness at about 35 MHz. A thinner foil would be preferable.

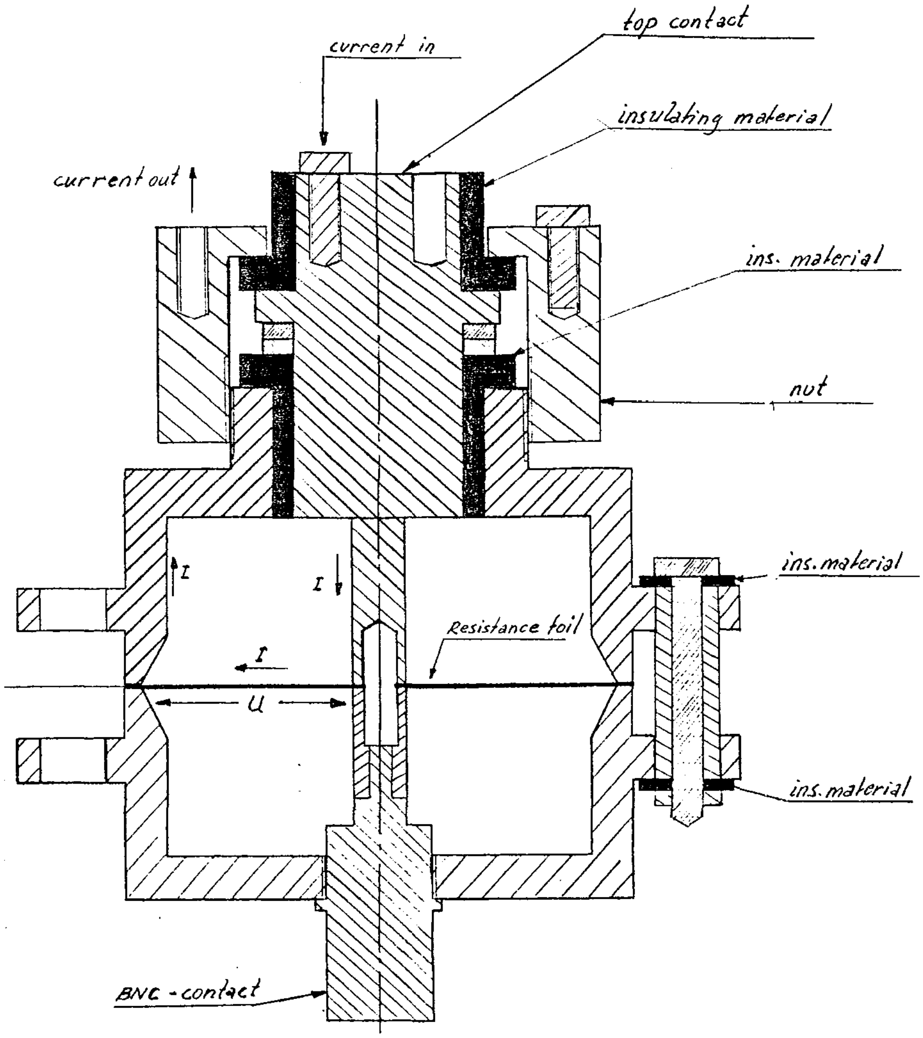


Figure 2.9: Current probe, 1.5 * natural size

3. CALIBRATION OF A DIODE ARRAY DETECTOR

3.1 INTRODUCTION

The Department of Atomic Physics, Lund Institute of Technology, uses a Tracor Northern 1710 multichannel analyzer together with Diode Array Rapid Scan Spectrometer (DARSS) modules for various kinds of spectrographic analyses. The DARSS detector head has 1024 individual light sensitive diodes placed closely together on a line. Each of these diodes is connected with a corresponding channel in the multichannel analyzer.

The DARSS detector head is mostly used together with some type of spectrograph. The spectrum to be examined is projected on the photodiode array. The spectral characteristic (light intensity as a function of wavelength) is then presented on the viewing screen of the analyzer. Thus we have a very powerful tool for spectrum analyses but until now there has also been a problem because the DARSS detector head was delivered uncalibrated. Because of this, accurate measurements could not be performed so far.

This chapter describes the computer programs, which have been written to calibrate spectral characteristics from the multichannel analyzer.

3.2 A BRIEF APPARATUS DESCRIPTION

3.2.1 THE DARSS DETCTOR HEAD

Figure 3.1 shows a drawing of the detector head. The used head designation is TN-1223-4GI. (I=Intensified). The detector head converts spectral information (energy) into video pulses. The heart of the detector head is a linear, self-scanned, silicon photodiode array with 1024 elements. The spectrum to be examined is projected on the photodiode array. The individual of the array are read out sequentially producing a train of pulses. The height of a pulse is proportional to the intensity of the light falling on the corresponding array element. Wavelength information is determined by the pulse position in the read out sequence. The spectral response of the array covers the range from 200 to 800 nm.

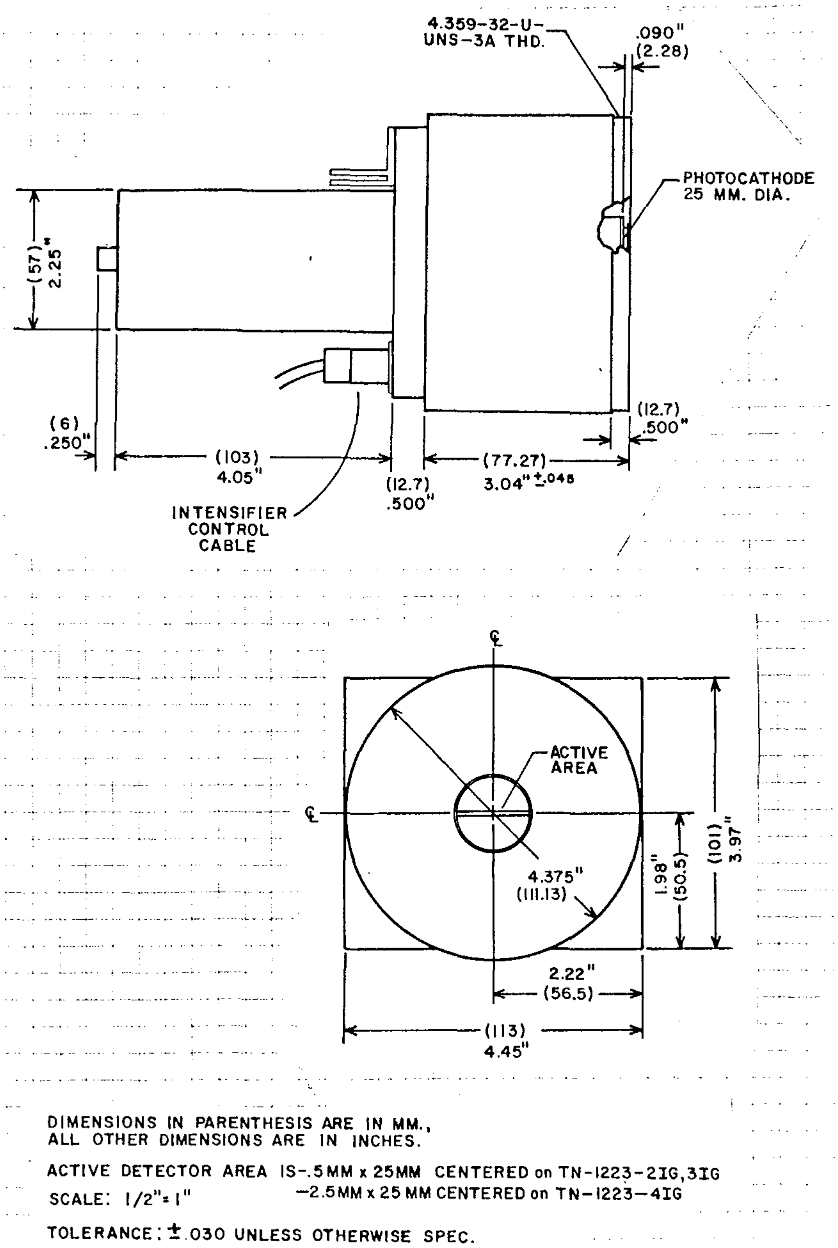


Figure 3.1: TN-1223 Gated intensified DARSS detector interface

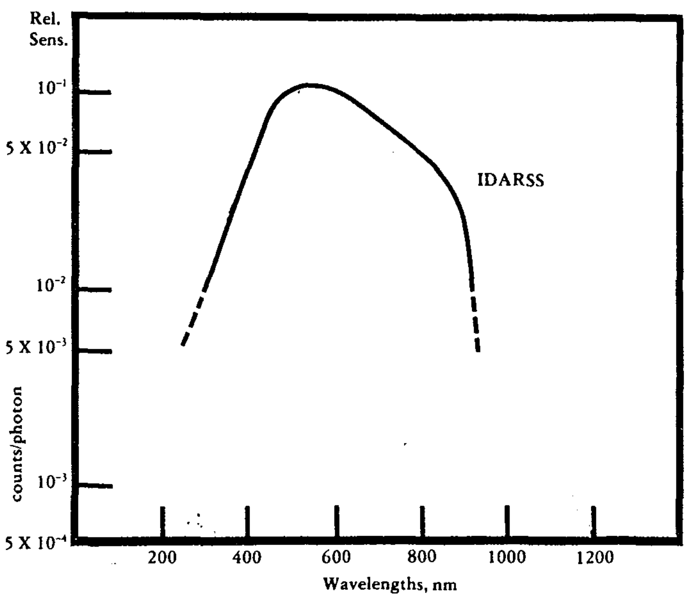


Figure 3.2: Relative spectral sensitivity of Intensified DARSS detector, given by the manufacturer

The actual spectral range measured by the system depends on the spectrograph used, other optical components and the geometry of these components. Together with the smallest spectrograph used by us (a Jobin Yvon UFS-200) the spectral range is from about 200 to 800 nm.

3.2.2 THE TN-1710 MULTICHANNEL ANALYZER

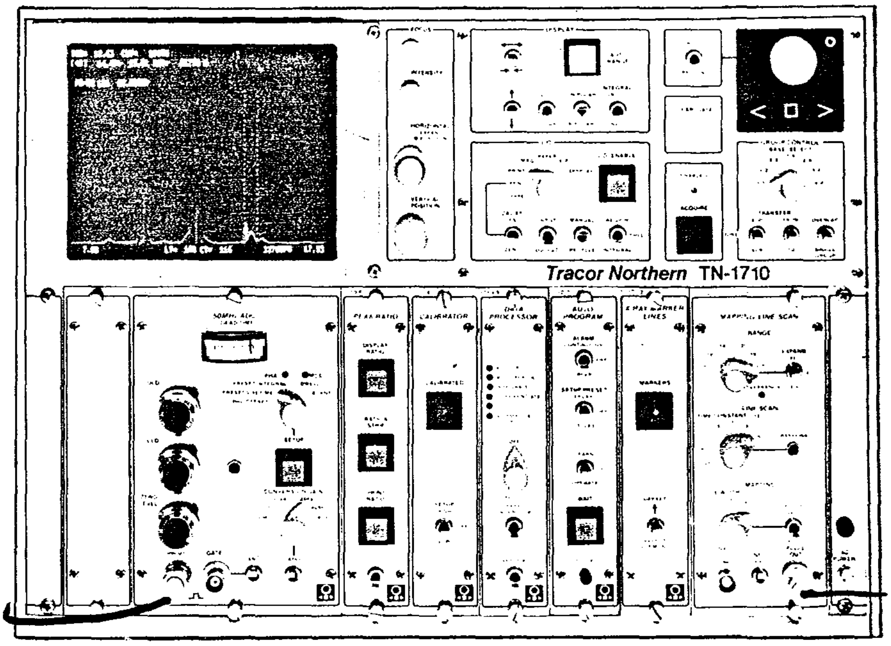


Figure 3.3: TN-1710 Multichannel analyzer

Figure 3.3 shows the front of a TN-1710. On the upper half of the front a screen for data displaying and several fundamental control knobs are placed. The control knobs allow manipulation of the curves on the screen, control of input and output, storage of data etc. The lower half of the analyzer consists of eleven positions which can be filled with plug-in units chosen from a large selection. In our case plug-in units designed for spectrum analysis and data manipulations, such as multiplying with a constant, logarithmic operations and data transfer have been chosen.

The TN-1710 analyzer has a built in micro-computer, which stores and manipulates data. The micro-computer memory consists of 4096 words. These are divided into four groups of 1024 words each. The words are numbered from 0 to 4095 and are also called "channels". 1024 is the maximum number of channels which can be connected to the detector head at the same time. When the detector head is illuminated with a spectrum, the 1024 diodes are scanned and values proportional to the light intensity falling on each diode are stored in the corresponding 1024 channels. As the size of the computer memory is 4096 words, 4 spectra can be stored if the resolution is 1024 values per spectrum. In many cases this high resolution is not needed. Therefore it is possible to chose a lower resolution, for example 512 values per spectrum (even lower is possible). This means that only every second value from the detector is stored in the computer memory. The computer memory is of semi-conductor type. When the power is turned of, all stored values disappear. In order to allow more permanent storage of data, it is possible to connect the analyzer to another computer or to an X/Y-recorder. We use a PDP-11 computer with floppy discs and a Hewlett-Packard X/Y-recorder. It is also possible to send data in the opposite direction in order to present computer stored spectra on the analyzer screen.

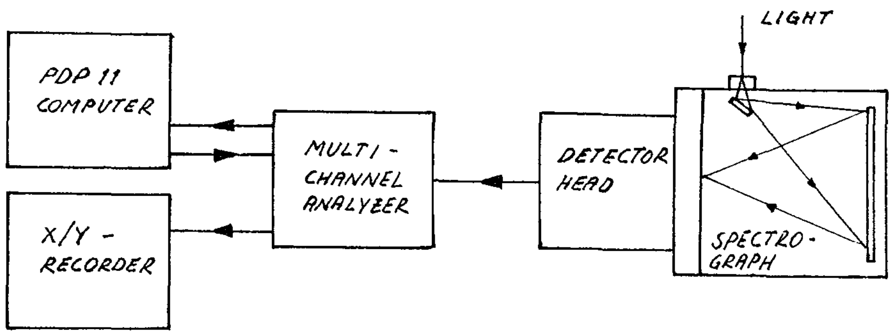


Figure 3.4: Apparatus setup.

Further information about these components is not needed to understand the problem and the computer programs, but in case of special interest, see operation manuals (3,4).

3.3 PROBLEM PRESENTATION. CALIBRATION METHODS.

Figure 3.2 shows the spectral sensitivity of the diodes, given by the manufacturer. The maximum sensitivity of the diodes is at about 500 nm. For longer as well as shorter wavelengths the sensitivity drops rapidly. One also finds sensitivity variations between the diodes when illuminating with monochromatic light.

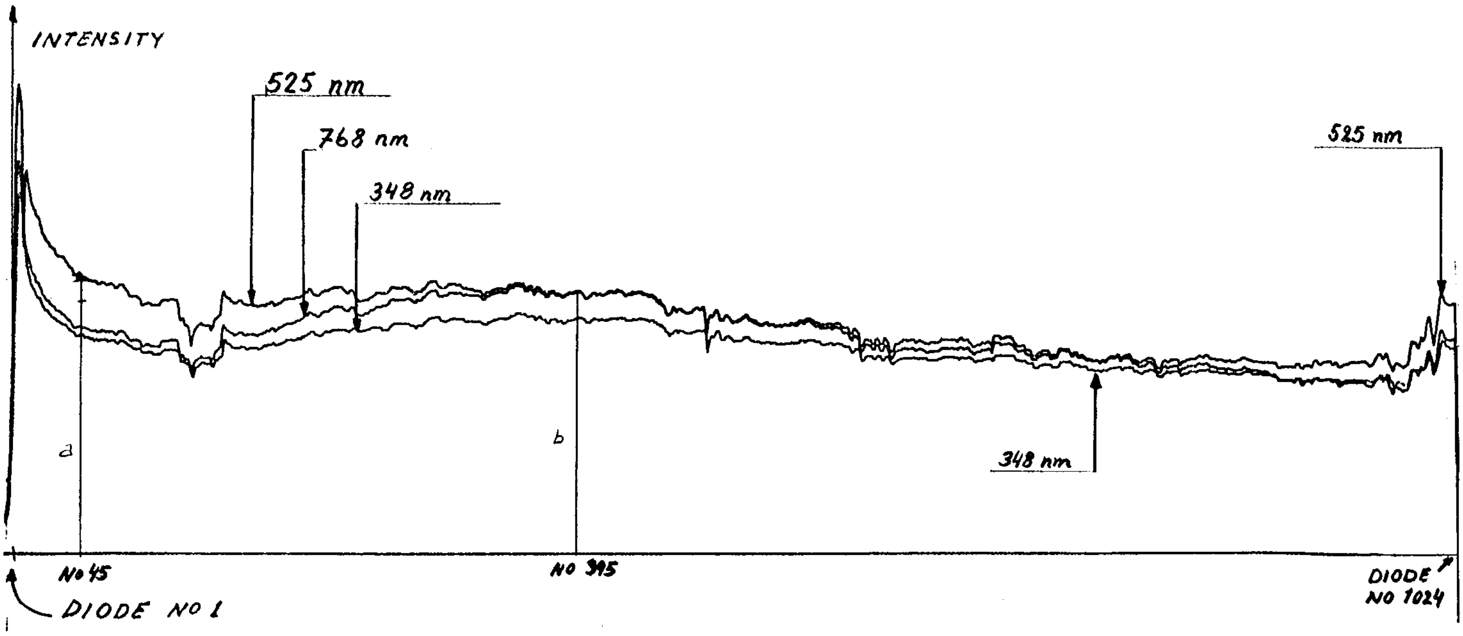


Figure 3.5: Sensitivity variation of diodes at different wavelengths.

The curves in Figure 3.5 were obtained by putting interference filters close to the diode array and illuminating with daylight. Three different filters with transmission wavelengths 348 nm (UV), 525 nm (visible) and 768 nm (IR) were used. The absolut level of these curves can not be compared due to different transmission coefficients.

The diode array is mainly used together with three different spectrographs. These are:

1. Jobin Yvon UFS-200 spectrometer, which covers the range from about 200 to 800 nm.

2. Jobim Yvon HR-1000, a 1 meter holographic grating spectrograph. The wavelength interval illuminating the diode array is about 20 nm.

3. 2 m Ebert spectrograph, a 2 meter grating spectrograph. The wavelength interval illuminating the diode array is about 2 nm, but depends on the grating beeing used.

Depending on the spectrograph beeing used, two different kinds of calibrations have to be done. When using spectrograph number one, different diodes are illuminated with light of different wavelengths. The higher the diode number, the higher is the wavelength. Thus it is necessary to calibrate both for spectral sensitivity of the individual diodes and for sensitivity variations between different diodes. Fortunately, this spectrograph is fixed so that a diode always senses the same wavelength. When using the other spectrographs, almost monochromatic light is illuminating the diode array. Then it is necessary only to calibrate for sensitivity variations between different diodes.

In order to calibrate the diode array together with spectrograph number one, a calibrated General Electric DXW 100 standard lamp was aquired. With the standard lamp illuminating the spectrograph entrance slit, a spectrum was obtained and stored on a PDP-11 computer file.

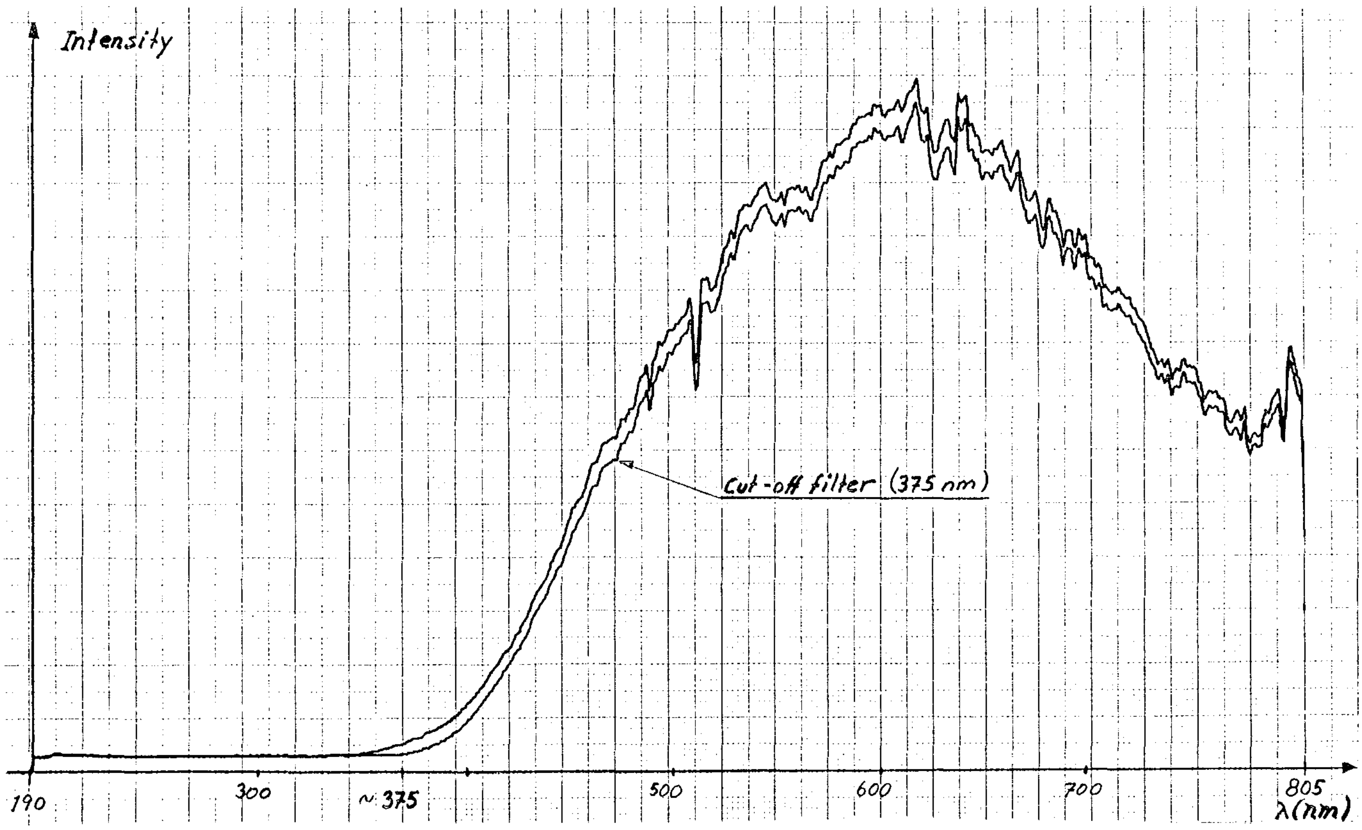


Figure 3.6: Standard lamp spectrum via diode array and Jobin Yvon UFS-200. Lower curve with cut-off filter (375 nm). Upper curve without cut-off filter.

From this a corrected spectrum was obtained using the calibration certificate data (Appendix B),by simply putting the values into the computer. For this correction, a well-known spectrum was needed in order to connect every channel number with a wavelength. For this purpose we let light from mercury fluorescent tubes illuminate the spectrograph and obtained two well-known mercury lines, 4358 Å and 5461 Å. With the help of these two lines and their corresponding multichannel analyzer channel numbers, wavelengths corresponding to all channel numbers were calculated, assuming linearity. Using the computer editor, the corrected spectrum was stored on another file.

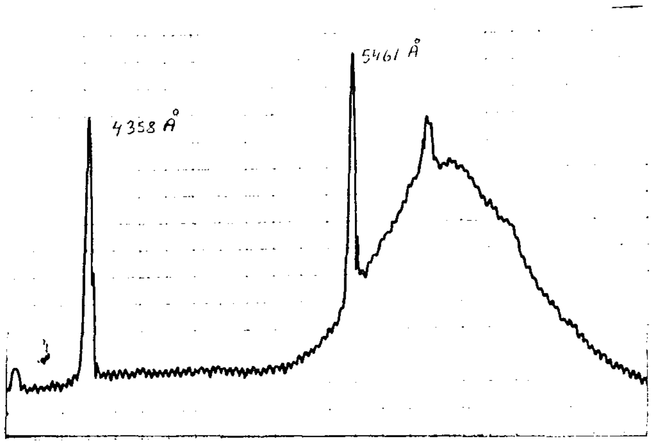


Figure 3.7: Hg fluorescent tube spectrum.

If we let X denote the intensity values in the corrected spectrum and let Y denote the values in the spectrum obtained directly from the standard lamp, we get calibration factors Z as:

$$Z = \frac{X}{Y}$$

One part of the computer program that was written multiplies a recorded spectrum with the calibration function. A calibration, made this way not only takes account of the sensitivity variation of the diodes but also of spectral variations pertinent to spectrograph number 1.

The standard lamp operates at 120 Volts and 7.9 Amperes, which corresponds to approximately 950 W. Therefore, the light intensity at the spectrometer entrance slit is high. The spectral characteristic of this light is given in Appendix B and figure

3.8. (Figure 3.8 is constructed from Appendix B data). A small part of the light falls in the UV-region.As the diode sensitivity and the standard lamp sensitivity drops rapidly for short wavelengths, a corresponding intensity drop would be expected in the standard lamp spectrum registered with spectrometer 1 and the diode array. But figure 3.6, the upper curve, shows a low intensity down to 190 nm. The relative intensity for wavelengths below 375 nm is approximately constant.

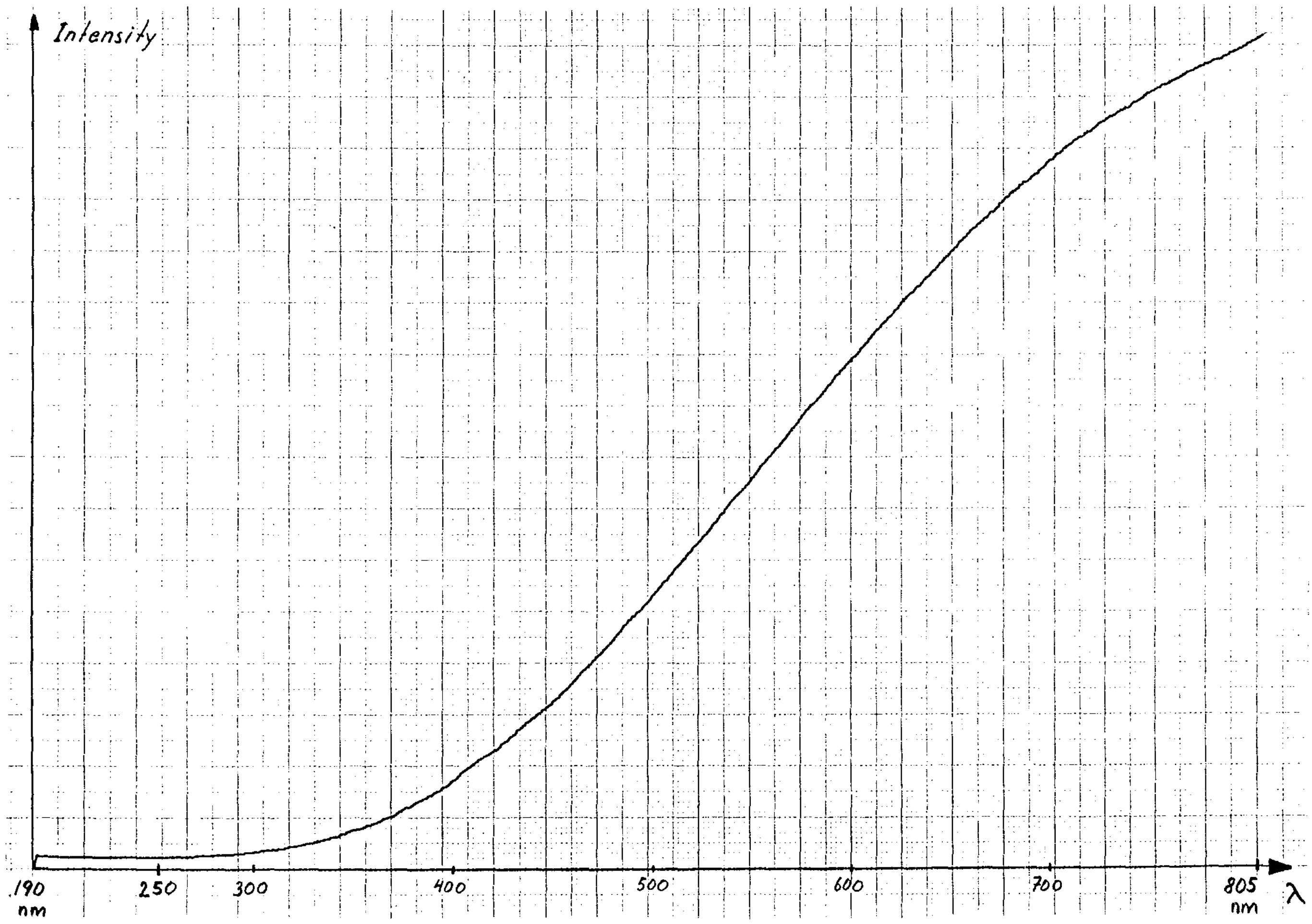


Figure 3.8: Standard lamp spectrum

In order to investigate this problem, a cut-off filter (375 nm) was placed in front of the entrance slit. This filter has no transmission below 375 nm, but the registered intensity at wavelengths below 375 nm was still the same.The conclusion is that some part of the visible and infrared light is scattered or reflected to the "ultraviolett part" of the diode array. This may happen because the spectrograph walls are not totally black and the grating may contain irregularities. Compared to ordinary experiments, the visible light intensity is very high, which makes the effect in the UV significant in this case.

Thus, each diode is illuminated with light of a wavelength corresponding to the diode number and with light of many other wavelengths. For diodes illuminated with ultraviolet light, the amount of scattered and reflected light is too high and affects the calibration too much. For diodes corresponding to wavelengths less than 375 nm the calibration must be performed in another way.

Two different transmission filters were used; one with 40% transmission at 374 nm and another with 18.4% transmission at 300 nm. By using these filters only a small part of the diode array is illuminated and is affected by a far smaller amount of scattered light, even when the standard lamp is used. Sensitivities for the diodes corresponding to the wavelengths 300 and 374 nm were calculated from transmission factors, standard lamp intensity and the intensity obtained via spectrograph 1 and diode aaray.

$$\text{Sensitivity} = \frac{\text{Obtained intensity}}{\text{Transmission} * \text{Standard lamp intensity}}$$

By standardizing the intensity at 300 nm to the 374 nm sensitivity a linear approximation for other diode sensitivities can be made. According to figure 3.2 the intensity drops linearly in a logarithmic scale. This approximation was carried out down to 250 nm. Below this wavelength no standard lamp data are known and very few experiments are performed. This approximation is very rough, but it can be improved by using some more calibration points in the interval 250 to 374 nm.

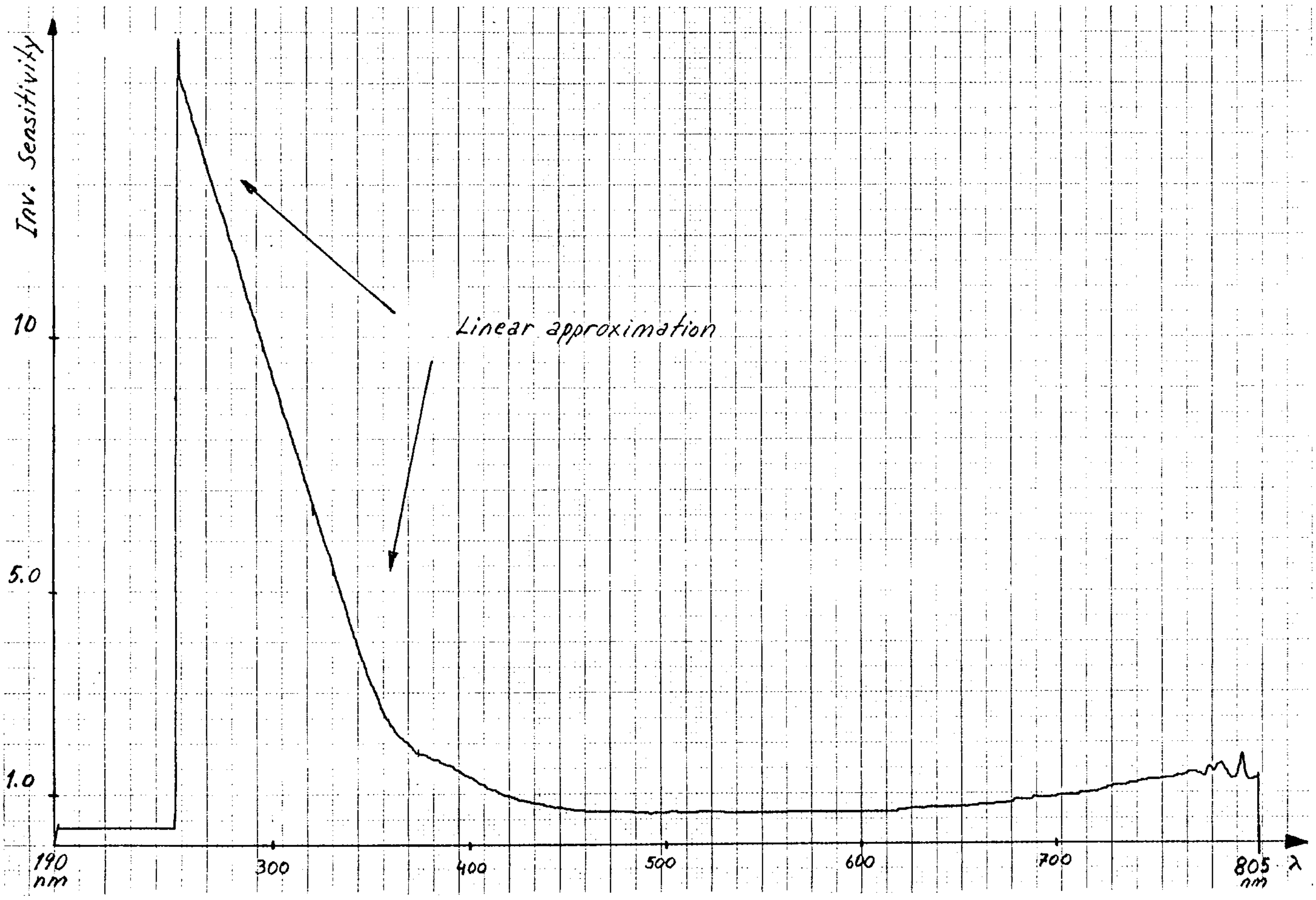


Figure 3.9: Inverted sensitivity, diode array together with spectrograph Jobin Yvon UFS-200.

Finally, a calibrated Hg fluorescent tube spectrum and an uncalibrated spectrum are shown in figure 3.10.

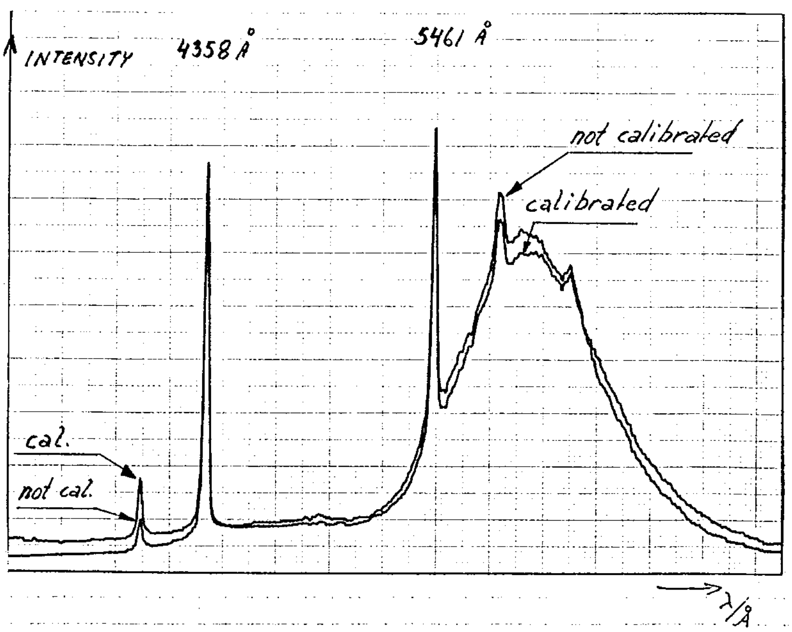


Figure 3.10: Calibrated and non-calibrated Hg fluorescent tube spectra.

To calibrate for sensitivity variations between the diodes, when either spectrograph 2 or 3 is used, data from one of the three sensitivity curves (these curves were also stored on a PDP-11 file) in figure 3.5 is used. Which one depends on the wavelength in the present experiment. (Note: When spectrographs 2 or 3 are used, light of almost the same wavelength illuminates all the diodes).

From figure 3.5 it can be seen that different diodes have different spectral sensitivity. Look for example at diode numbers 45 and 395 marked in figure 3.5. This kind of variation in spectral sensitivity is surprising but it was considered beyond the scope of the present work to investigate this further. If Y denotes the sensitivity values for the diodes, the calibration factors Z (different for all diodes) are in this case

$$Z = \frac{1}{Y}$$

Calibrations of spectra obtained are then performed by multiplying actual intensities with Z. Calibrations made in this way affects the absolute level of the spectrum, but in applications of interest to us, only relative effects are considered.

3.4 COMPUTER PROGRAMS

To perform the previously mentioned calibrations, a program package consisting of one calibration program and two service routines, have been written.

The calibration program, called SPECOR, consists of a main routine and two service routines, called SPD and SPC. The SPD routine has nothing to do with calibration and is described in the next chapter. SPD is included in the package for practical reasons.

The user communicates with the program during execution with the help of questions asked by the program. These questions are formulated to avoid misunderstandings. Therefore it seems unnessecary to give a detailed program description.

The main routine reads in the desired spectrum, which has to be stored on a PDP-11 file. When calibration is to be performed subroutine SPC is called. SPC asks questions about the spectrograph beeing used and about the wavelength region. After a performed calibration return is made to the main routine. The main routine asks for a new file name, and the corrected spectrum is stored on this file. Now, this spectrum can be studied on the multichannel analyzer screen or the curve can be read out on an X/Y- recorder. Most program statements are used for data administration and questioning.

The service routines DNORM and DNORM1 create files containing the calibration factors Z mentioned previously. DNORM reads the files containing the curves in figure 3.6 and DNORM1 reads the file containing the standard lamp spectrum, see figure 3.6. With the help of these files some simple calculations are made and the results Z are read out to new files. Using new files makes reading easier.

3.4.1 THE SPD-ROUTINE

In some experiments, for example CARS (1), it is of interest to divide one spectrum by another. For this purpose the computer program SPD has been written and connected to the SPECOR program as a subroutine.

SPD is a simple routine and the only input required is two pairs of channel numbers, which specify two groups of channels. The channel numbers given represent the lowest and highest channel numbers in each group. Both groups must contain the same number of channels. The intensity stored in the first channel of the second group is divided by the intensity stored in the first channel of the first group and so on. The results are stored in the second group channels on a new file.

3.5 INACCURACY

The calibration affects the absolute level of the spectrum. The inaccuracy discussed refers to relative levels.

Spectrograph 1

When calibrating spectra from spectrograph one, the inaccuracy is mainly given by the inaccuracy in the standard lamp calibration. Below 250 nm no values are given. Thus there is no accuracy in the interval 200-250 nm. The inaccuracy is +- 5 % in the interval 375-400 nm ind +- 3 % in the interval 400-805 nm. The computer manipulation is assumed not to affect these values.

In the wavelength interval 250-375 nm two transmission filters were used. The inaccuracy in the transmission coefficients is estimated to be +- 2 %, which added to the former mentioned 5 % results in +- 5.4 %. For wavelengths between 250 and 374 nm the inaccuracy is approximately another 5% larger because of the linear sensitivity drop approximation. See figure 3.9.

Spectrographs 2 or 3

Calibration for sensitivity variations of the diodes is based on data forming the curves in figure 3.5. If the actual spectrum subject to calibration is in a wavelength region close to any of the three wavelengths 348, 525 or 768 nm the inaccuracy is estimated to be less than +- 1 %. (No errors introduced by computer manipulation). Inaccuracy estimation will be more difficult if the actual spectrum lies far from any of the three wavelengths.

Suppose that a spectrum, centered around 647 nm, from spectrograph two or three is subject to calibration. The user is asked, by the program, to give one of the three wavelengths which lies nearest 647 nm. In this case, the answer is either 525 or 768 nm. Irrespective of the answer an error will be introduced because the curves are not parallel. The error introduced in this example will be the difference between the assumed 647 nm curve and the chosen calibration curve. The relative error is the ratio between this difference and the actual 647 nm sensitivity. In figure 3.5, two lines, a and b, have been drawn. Line a approximately corresponds to diode number 45 and line b to diode number 395. The largest difference between the two curves is at line a and the smallest at b (for example). A corresponding sensitivity curve for 647 nm may be assumed to be placed between and on the same distance to the two other curves. In this case, the maximum inaccuracy can be calculated to +- 10 % by using figure 3.5. This value estimates the maximum inaccuracy which is valid for diodes with numbers from 0 to 150. For most other diodes the maximum inaccuracy is estimated to +-5 %.

4 DOUBLE SLIT

4.1 INTRODUKTION

The previously described diode array offers a sufficiently high resolution for the simultaneous recording of two different spectra. The two spectra can be projected on the array by using two well separated entrance slits. This double slit can be useful in CARS experiments.

4.2 DESIGN

Three double slits with different slit widths and a slit holder was designed. The double slits were cut out of 1 mm thick polyethylene plastic plates with a CO_2-laser. The plates were formed to fit the double slit holder. The slit distance 13 mm was chosen. This is 0.5 mm more than half the diode array length. The two spectra may then occupy approximately half of the array each.

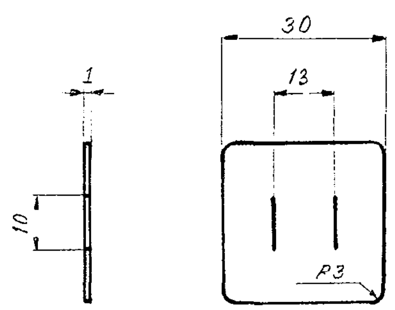


Figure 4.1: Double slit plate

Appendix C sida 1

```
      PROGRAM SPECOR

      PROGRAMMET KORRIGERAR SPEKTRUM FRÅN TRACOR NORTHERN MÅNGKANAL
      ANALYSATOR MED TILLHÖRANDE DIODARRAY OCH MONOKROMATOR.

      BYTE FILNAMN(14),LINE(64),NAMN(6),LINE1(64),LINE2(64),LINE3(64),
     &ANSWER
      DIMENSION XAXE(128),YAXE1(1024),YAXE2(1024)
      INTEGER NUMB,K1,N1,N2,K
      COMMON YAXE1
      INTEGER*4 YAXE2(1024)
      ANSWER='Y'

    1 TYPE*,
      TYPE*,'WHAT KIND OF FILE MANIPULATION DO YOU WANT TO DO?'
      TYPE*,'1) SPECTRUM CORRECTION'
      TYPE*,'2) SPECTRUM DIVISION (WHEN DOUBLE SLIT HAS BEEN USED)'
      TYPE*,'ANSWER (1/2)'
      ACCEPT 100,NUMB
      IF(NUMB.NE.1.AND.NUMB.NE.2) GO TO 1
      GO TO 2
  993 TYPE*,
      TYPE*,'FILE DO NOT EXIST ON DRIVE DY1:(TRY ANOTHER NAME!)'
    2 TYPE*,
      TYPE*,'WRITE THE NAME OF THE FILE YOU WANT TO MANIPULATE'
      TYPE*,'FILE MUST BE ON DRIVE DY1 AND OF TYPE TND'
      TYPE*,'MAXIMUM FIVE LETTERS IN FILENAME'
      ACCEPT 200,NAMN
      FILNAMN(1)='D'
      FILNAMN(2)='Y'
      FILNAMN(3)='1'
      FILNAMN(4)=':'
C
      DO 3 I=5,10
      K1=I
      IF(NAMN(I-4).EQ.' ') GO TO 4
      FILNAMN(I)=NAMN(I-4)
    3 CONTINUE
C
      K1=K1+1
    4 FILNAMN(K1)='.'
      FILNAMN(K1+1)='T'
      FILNAMN(K1+2)='N'
      FILNAMN(K1+3)='D'
      IF(K1+3.EQ.14) GO TO 5
C
      DO 6 I=K1+4,14
      FILNAMN(I)=' '
    6 CONTINUE
C
    5 OPEN(UNIT=3,NAME=FILNAMN,ERR=993,TYPE='OLD')
      READ(3,300) LINE
      READ(3,300) LINE1
      READ(3,300) LINE2
      READ(3,300) LINE3
C
      DO 7 K=1,128
      N2=8*K
      N1=N2-7
      READ(3,300,END=997) LINE
      DECODE(64,400,LINE,ERR=995) XAXE(K),(YAXE1(I),I=N1,N2)
    7 CONTINUE
C
      CLOSE(UNIT=3)
C
C     SUBRUTINHOPP
      IF(NUMB.EQ.1) CALL SPC
      IF(NUMB.EQ.2) CALL SPD
C
      DO 9 I=1,1024
      YAXE2(I)=AINT(YAXE1(I))
    9 CONTINUE
```

```
C     PROGRAMMET KORRIGERAR SPEKTRUM FRAN TRACOR NORTHERN MÅNGKANAL
C     ANALYSATOR MED TILLHÖRANDE DIODARRAY OCH MONOKROMATOR.
C
      BYTE FILNAMN(14),LINE(64),NAMN(6),LINE1(64),LINE2(64),LINE3(64),
     &ANSWER
      DIMENSION XAXE(128),YAXE1(1024),YAXE2(1024)
      INTEGER NUMB,K1,N1,N2,K
      COMMON YAXE1
C     INTEGER*4 YAXE2(1024)
      ANSWER='Y'
C
    1 TYPE*,
      TYPE*,'WHAT KIND OF FILE MANIPULATION DO YOU WANT TO DO?'
      TYPE*,'1) SPECTRUM CORRECTION'
      TYPE*,'2) SPECTRUM DIVISION (WHEN DOUBLE SLIT HAS BEEN USED)'
      TYPE*,'ANSWER (1/2)'
      ACCEPT 100,NUMB
      IF(NUMB.NE.1.AND.NUMB.NE.2) GO TO 1
      GO TO 2
  993 TYPE*,
      TYPE*,'FILE DO NOT EXIST ON DRIVE DY1:(TRY ANOTHER NAME!)'
    2 TYPE*,
      TYPE*,'WRITE THE NAME OF THE FILE YOU WANT TO MANIPULATE'
      TYPE*,'FILE MUST BE ON DRIVE DY1 AND OF TYPE TND'
      TYPE*,'MAXIMUM FIVE LETTERS IN FILENAME'
      ACCEPT 200,NAMN
      FILNAMN(1)='D'
      FILNAMN(2)='Y'
      FILNAMN(3)='1'
      FILNAMN(4)=':'
C
      DO 3 I=5,10
      K1=I
      IF(NAMN(I-4).EQ.' ') GO TO 4
      FILNAMN(I)=NAMN(I-4)
    3 CONTINUE
C
      K1=K1+1
    4 FILNAMN(K1)='.'
      FILNAMN(K1+1)='T'
      FILNAMN(K1+2)='N'
      FILNAMN(K1+3)='D'
      IF(K1+3.EQ.14) GO TO 5
C
      DO 6 I=K1+4,14
      FILNAMN(I)=' '
    6 CONTINUE
C
    5 OPEN(UNIT=3,NAME=FILNAMN,ERR=993,TYPE='OLD')
      READ(3,300) LINE
      READ(3,300) LINE1
      READ(3,300) LINE2
      READ(3,300) LINE3
C
      DO 7 K=1,128
      N2=8*K
      N1=N2-7
      READ(3,300,END=997) LINE
      DECODE(64,400,LINE,ERR=995) XAXE(K),(YAXE1(I),I=N1,N2)
    7 CONTINUE
C
      CLOSE(UNIT=3)
C
C     SUBRUTINHOPP
      IF(NUMB.EQ.1) CALL SPC
      IF(NUMB.EQ.2) CALL SPD
C
      DO 9 I=1,1024
      YAXE2(I)=AINT(YAXE1(I))
```

```
      CONTINUE
C
C     UTSKRIFT PÅ NY FIL
      TYPE*,
      TYPE*,'PLEASE GIVE A NEW NAME FOR THE OUTPUT FILE'
      TYPE*,'MAXIMUM FIVE LETTERS IN FILENAME'
      TYPE*,'FILE NAME WILL BE FOLLOWED BY .TND IN FILE CATALOGUE'
      ACCEPT 200,NAMN
C
      DO 10 I=5,10
      K1=I
      IF(NAMN(I-4).EQ.' ') GO TO 11
      FILNAMN(I)=NAMN(I-4)
   10 CONTINUE
C
      K1=K1+1
   11 FILNAMN(K1)='.'
      FILNAMN(K1+1)='T'
      FILNAMN(K1+2)='N'
      FILNAMN(K1+3)='D'
      IF(K1+3.EQ.14) GO TO 12
C
      DO 13 I=K1+4,14
      FILNAMN(I)=' '
   13 CONTINUE
C
   12 OPEN(UNIT=2,ERR=991,NAME=FILNAMN,TYPE='NEW')
   18 TYPE*,
      TYPE*,'DO YOU WANT TO PUT A TEXT-LABLE ON YOUR NEW CURVE?(Y/N)'
      ACCEPT 500,ANSWER
      IF(ANSWER.EQ.'N') GO TO 14
      IF(ANSWER.EQ.'Y') GO TO 17
      GO TO 18
   17 TYPE*,
      TYPE*,'WRITE YOUR LABLE (MAX 64 LETTERS)'
      ACCEPT 300,LINE1
C
   14 WRITE(2,700) LINE1
      WRITE(2,700) LINE1
      WRITE(2,700) LINE2
      WRITE(2,700) LINE3
C
      DO 15 K=1,128
      N2=8*K
      N1=N2-7
      ENCODE(64,600,LINE,ERR=989) XAXE(K),(YAXE2(I),I=N1,N2)
         DO 16 I=14,63,7
         LINE(I)=' '
   16    CONTINUE
      WRITE(2,700) LINE
   15 CONTINUE
C
      GO TO 999
C
C     FELMEDDELANDEN MM
  997 TYPE*,'FILE END TOO SOON (SHORTER THAN 1024 POINTS)'
      GO TO 999
  995 TYPE*,'DECODING ERROR'
      TYPE*,'SEE IF FILE VALUES ARE CORRECTLY ARRANGED'
      GO TO 999
  991 TYPE*,'SAVING FILE CAN NOT BE OPENED'
      GO TO 999
  989 TYPE*,'IT IS NOT POSSIBLE TO ENCODE YOUR NEW DATA'
  999 CLOSE(UNIT=2)
C
  100 FORMAT(I1)
  200 FORMAT(6A1)
  300 FORMAT(64A1)
  400 FORMAT(9F7.0)
  500 FORMAT(A1)
  600 FORMAT(F7.1,8F7.0)
  700 FORMAT(' ',64A1)
C
```

```
      STOP
      END



      SUBROUTINE SPC

      COMMON YAXE1
      DIMENSION YAXE1(1024),CF(103),DIODF(1024)
      INTEGER CHNR,CL,CH,WAVEL(103),W1,W2,LAMB1,LAMB2,I,J,K,NSPNR,A,B,
     &NCH,IWL1,SCALE
      REAL WPCH,IWL,TNMAX
C
    3 TYPE*,
      TYPE*,'WHAT TYPE OF MONOCHROMATOR HAS BEEN USED?'
      TYPE*,'1) SMALL MONOCHROMATOR'
      TYPE*,'2) MEDIUM MONOCHROMATOR'
      TYPE*,'3) 2M EBERT SPECTROGRAPH'
      TYPE*,'ANSWER(1/2/3)'
      ACCEPT 100,MNR
      IF(MNR.GT.3.OR.MNR.LT.1) GO TO 3
C
   30 TYPE*,
      TYPE*,'DO THE 1024 CHANNELS CONTAIN ONE OR TWO SPECTRA?'
      TYPE*,'(ANSWER 1/2)'
      ACCEPT 100,NSPNR
      IF(NSPNR.EQ.1.OR.NSPNR.EQ.2) GO TO 2
      GO TO 30
C
    2 GO TO (1,40,40) MNR
      GO TO 3
C
C     LILLA MONOKROMATORN
    1 OPEN(UNIT=3,NAME='MONOC1',ERR=994,TYPE='OLD')
      GO TO 50
C
C     MELLANMONOKROMATORN OCH 2M EBERT SPEKTROGRAF
   40 TYPE*,
      TYPE*,'FROM WHAT REGION IS YOUR SPECTRUM?'
      TYPE*,'1) INFRARED          (768NM)'
      TYPE*,'2) VISIBLE           (525NM)'
      TYPE*,'3) ULTRAVIOLET       (348NM)'
      TYPE*,'ANSWER (1/2/3)'
      ACCEPT 100,NREG
      IF(NREG.GT.3.OR.NREG.LT.1) GO TO 40
C
      GO TO (61,62,63) NREG
      GO TO 40
   61 OPEN(UNIT=3,NAME='IRKOMP',ERR=994,TYPE='OLD')
      GO TO 50
   62 OPEN(UNIT=3,NAME='VIKOMP',ERR=994,TYPE='OLD')
      GO TO 50
   63 OPEN(UNIT=3,NAME='UVKOMP',ERR=994,TYPE='OLD')
C
   50 READ(3,700) DIODF
      CLOSE(UNIT=3)
C
      DO 51 I=1,512
      K=NSPNR*(I-1)+1
      YAXE1(I)=YAXE1(I)*DIODF(K)
   51 CONTINUE
C
      DO 52 I=513,1024
      K=NSPNR*(I-1-(NSPNR-1)*512)+1
      YAXE1(I)=YAXE1(I)*DIODF(K)
   52 CONTINUE
```

```
   52 CONTINUE
C
C       OVERFLOW TEST
   32 TNMAX=1.0
      YAXE1(1)=10.
      YAXE1(2)=10.
      YAXE1(3)=10.
      YAXE1(4)=10.
      YAXE1(1021)=10.
      YAXE1(1022)=10.
      YAXE1(1023)=10.
      YAXE1(1024)=10.
      IF(NSPNR.EQ.1) GO TO 33
      YAXE1(511)=10.
      YAXE1(512)=10.
      YAXE1(513)=10.
      YAXE1(514)=10.
C
   33 DO 24 L=1,1024
      TNMAX=AMAX1(TNMAX,YAXE1(L))
   24 CONTINUE
C
      IF(TNMAX.GT.999999.) GO TO 25
      GO TO 26
   25 TYPE*,
      TYPE*,'WARNING: VALUES EXCEED 1,000,000 WHICH CAN NOT BE '
      TYPE*,'ACCEPTED BY TRACOR NORTHERN ANALYZER'
      TYPE*,'AUTOMATIC SCALING WILL BE PERFORMED'
      SCALE=TNMAX/950000.
C
      DO 27 I=1,1024
      YAXE1(I)=YAXE1(I)/SCALE
   27 CONTINUE
C
      GO TO 26
  994 TYPE*,
      TYPE*,'READING ERROR'
      STOP
C
  100 FORMAT(I1)
  200 FORMAT(1X,'CHANNEL NO  ',I4,'  CORRESPONDS TO')
  300 FORMAT(A1)
  400 FORMAT(I4)
  500 FORMAT(1X,'VALUES FOR CL,CH,LAMB1,LAMB2 ARE',//,1X,4I7)
  600 FORMAT(I4)
  700 FORMAT(F10.4)
  800 FORMAT(1X,'WAVELENGTH  ',I4)
C
   26 RETURN
      END
C
C
C
C
C
C
C
C
C
C
      SUBROUTINE SPD
C
      COMMON YAXE1
      DIMENSION YAXE1(1024)
      INTEGER CHNL1,CHNL2,CHNL3,CHNL4,IA,NCH
      REAL FACT,TNMAX,SCALE
C
   10 IA=0
      TYPE*,
      TYPE*,'WHICH CHANNELS DO YOU WANT TO DIVIDE?'
      TYPE*,'THE CHANNELS SHOULD BE GIVEN IN TWO GROUPS,'
      TYPE*,'WHERE THE CHANNELS IN THE SECOND GROUP WILL BE'
```

```
      TYPE*,' DIVIDED WITH THE CHANNELS IN THE FIRST GROUP.'
      TYPE*,'CHNL1 REFERS TO THE LOWEST CHANNEL NO IN THE'
      TYPE*,'FIRST GROUP, AND CHNL2 REFERS TO THE HIGHEST ONE.'
      TYPE*,'SIMILAR ORDER FOR CHNL3 AND CHNL4 IN THE 2:ND GROUP.'
      TYPE*,
      TYPE*,'BOTH GROUPS MUST CONTAIN THE SAME NUMBER OF CHANNELS'
      TYPE*,
      TYPE*,'THE RESULT CAN BE FOUND IN CHANNELS CHNL3-CHNL4'
      TYPE*,'OBSERVE THAT OTHER VALUES THAN THOSE IN'
      TYPE*,'CHNL3-CHNL4 MAY BE CHANGED DURING CALCULATIONS'
      TYPE*,
    4 TYPE*,'CHNL1='
      ACCEPT 100,CHNL1
      IF(IA.EQ.1) GO TO 8
    5 TYPE*,'CHNL2='
      ACCEPT 100,CHNL2
      IF(IA.EQ.1) GO TO 8
    6 TYPE*,'CHNL3='
      ACCEPT 100,CHNL3
      IF(IA.EQ.1)GO TO 8
    7 TYPE*,'CHNL4='
      ACCEPT 100,CHNL4
C
    8 IA=0
      TYPE*,
      WRITE(7,200) CHNL1,CHNL2,CHNL3,CHNL4
    1 TYPE*,
      TYPE*,'DO YOU WANT TO CHANGE ANYONE OF THESE?(Y/N)'
      ACCEPT 300,ANSWER
      IF(ANSWER.EQ.'Y') GO TO 2
      IF(ANSWER.EQ.'N') GO TO 3
      GO TO 1
C
    2 IA=1
      TYPE*,
      TYPE*,'WHICH CHANNEL NO DO YOU WANT TO CHANGE?(1/2/3/4)'
      ACCEPT 400,NCH
      GO TO (4,5,6,7) NCH
      GO TO 2
C
C     INDATA TEST
    3 IF(CHNL2-CHNL1.NE.CHNL4-CHNL3) GO TO 30
      IF(CHNL1.LT.1.OR.CHNL1.GT.1024) GO TO 30
      IF(CHNL2.LT.1.OR.CHNL2.GT.1024) GO TO 30
      IF(CHNL3.LT.1.OR.CHNL3.GT.1024) GO TO 30
      IF(CHNL4.LT.1.OR.CHNL4.GT.1024) GO TO 30
      GO TO 15
   30 TYPE*,
      TYPE*,'ERROR IN INPUT DATA, YOU MUST REPEAT THE INPUT PROCEDURE'
      TYPE*,
      GO TO 10
C
   15 TYPE*,
      TYPE*,'DO YOU WANT TO MULTIPLY THE VALUES BELONGING TO'
      TYPE*,'CHNL1-CHNL2 WITH A FACTOR?(Y/N)'
      ACCEPT 300,ANSWER
      IF(ANSWER.EQ.'Y') GO TO 16
      IF(ANSWER.EQ.'N') GO TO 17
      GO TO 15
   16 TYPE*,
      TYPE*,'GIVE THE FACTOR PLEASE (F-FORMAT F12.5)'
      ACCEPT 500,FACT
      TYPE*,
      WRITE(7,600) FACT
      TYPE*,
      TYPE*,'DO YOU WANT TO CHANGE IT?(Y/N)'
      ACCEPT 300,ANSWER
      IF(ANSWER.EQ.'N') GO TO 18
      GO TO 16
C
   18 DO 19 I=CHNL1,CHNL2
      YAXE1(I)=YAXE1(I)*FACT
   19 CONTINUE
```

```
      CONTINUE

    / K=CHNL1

      DO 20 I=CHNL3,CHNL4
      IF(YAXE1(I).EQ.0.) YAXE1(I)=1.0
      IF(YAXE1(K).EQ.0.) YAXE1(K)=1.0
      YAXE1(I)=YAXE1(I)/YAXE1(K)
      K=K+1
   20 CONTINUE

      OVERFLOW-TEST
      TNMAX=1.0

      DO 21 I=1,1024
      TNMAX=AMAX1(TNMAX,YAXE1(I))
   21 CONTINUE
C
      IF(TNMAX.GT.999999.) GO TO 22
      GO TO 24
   22 TYPE*,
      TYPE*,'WARNING: VALUES EXCEED 1,000,000 WHICH CAN NOT BE ACCEPTED'
      TYPE*,'BY TRACOR NORTHERN ANALYZER'
      TYPE*,'AUTOMATIC SCALING WILL BE PERFORMED'
      SCALE=TNMAX/950000.
C
   23 DO 24 I=1,1024
      YAXE1(I)=YAXE1(I)/SCALE
   24 CONTINUE
C
C
  100 FORMAT(I4)
  200 FORMAT(1X,'GIVEN VALUES FOR CHNL1-CHNL4 ARE',//1X,4I6)
  300 FORMAT(A1)
  400 FORMAT(I1)
  500 FORMAT(F12.5)
  600 FORMAT(1X,'GIVEN MULTIPLICATION FACTOR IS',//1X,F12.5)
C
      RETURN
      END
```

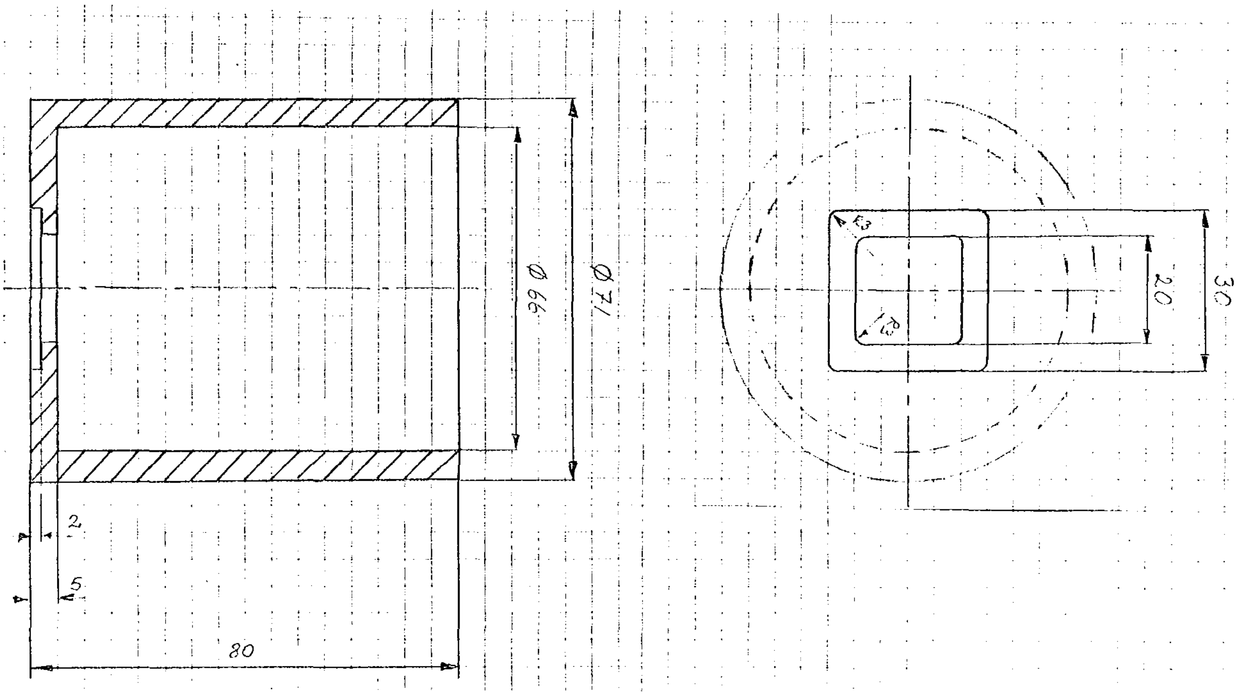
The CO_2 laser power was around 40 W, which was not sufficient to cut metallic plates. Metallic plates would be prefered since the slit walls might be smoother, but as can be seen from chapter 4.3 the result was very good with PVC plastic plates.

The CO_2 laser has been built at the department of Atomic Physics, Lund Institute of Technology, and the parameters given in table 4.1 are the interesting parameters for running this laser. The CO_2 laser uses a mixture of N_2, He and CO_2 gases. Table 4.1 documents the laser adjustment for cutting slits of widhts 0.2, 0.4 and 1.0 mm.

Table 4.1 Laser parameters for slit-cutting

Parameters	Slit width (mm)		
	0.2	0.4	1.0
Power (W)		38	
N_2 pressure (scale div)		9	
He pressure (scale div)		6	
CO_2 pressure (scale div)		7.5	
Total pressure (mbar)		15	
Current (mA)		100	
Lens focal length (inch)		1.5	
Number of sweeps	1	2	2
Speed (mm/s)	25	35	15
Distance holder-plastic plate (mm)	2.5	2.5	4.5

The double slit holder was designed to fit a Jobin Yvon HR1000 spectrograph. It consists of a brass tube with a special plate in one of the ends, to which the slit plates are put.



4.2 Double slit holder

4.3 RESULTS

The 0.2 mm double slit was chosen for testing. It was compared with the ordinary spectrograph entrance slit, which was adjusted to 0.2 mm. The slits were illuminated with light from a sodium lamp and the doublet at 5890 Å was studied. The figures 4.3 and 4.4 show the obtained spectra from the ordinary slit and the double slit respectively. The double slit resolution is at least as good as the entrance single-slit resolution.

When projecting two different spectra, which is the normal use of the double slit, one demands has to be put on the incoming light. The two incoming light beams must be of almost the same wavelength since they use the same grating.

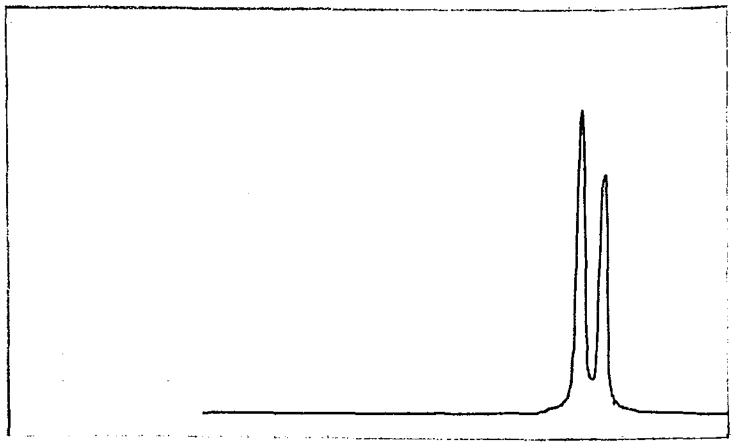


Figure 4.3: Single slit sodium spectrum

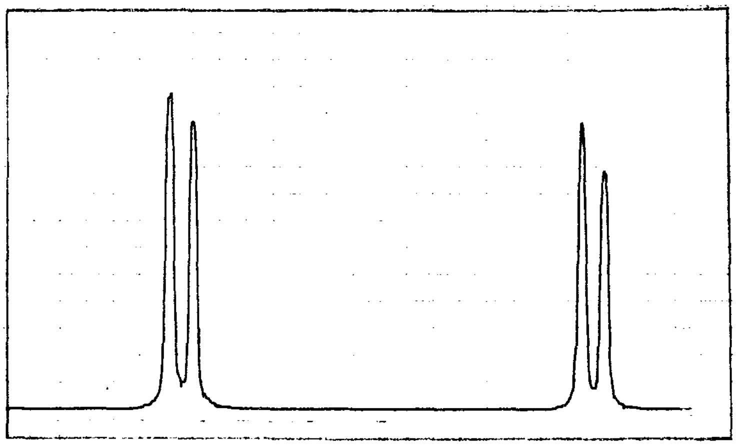


Figure 4.4: Double slit sodium spectrum

5 REFERENCES

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6. ACKNOWLEDGEMENTS

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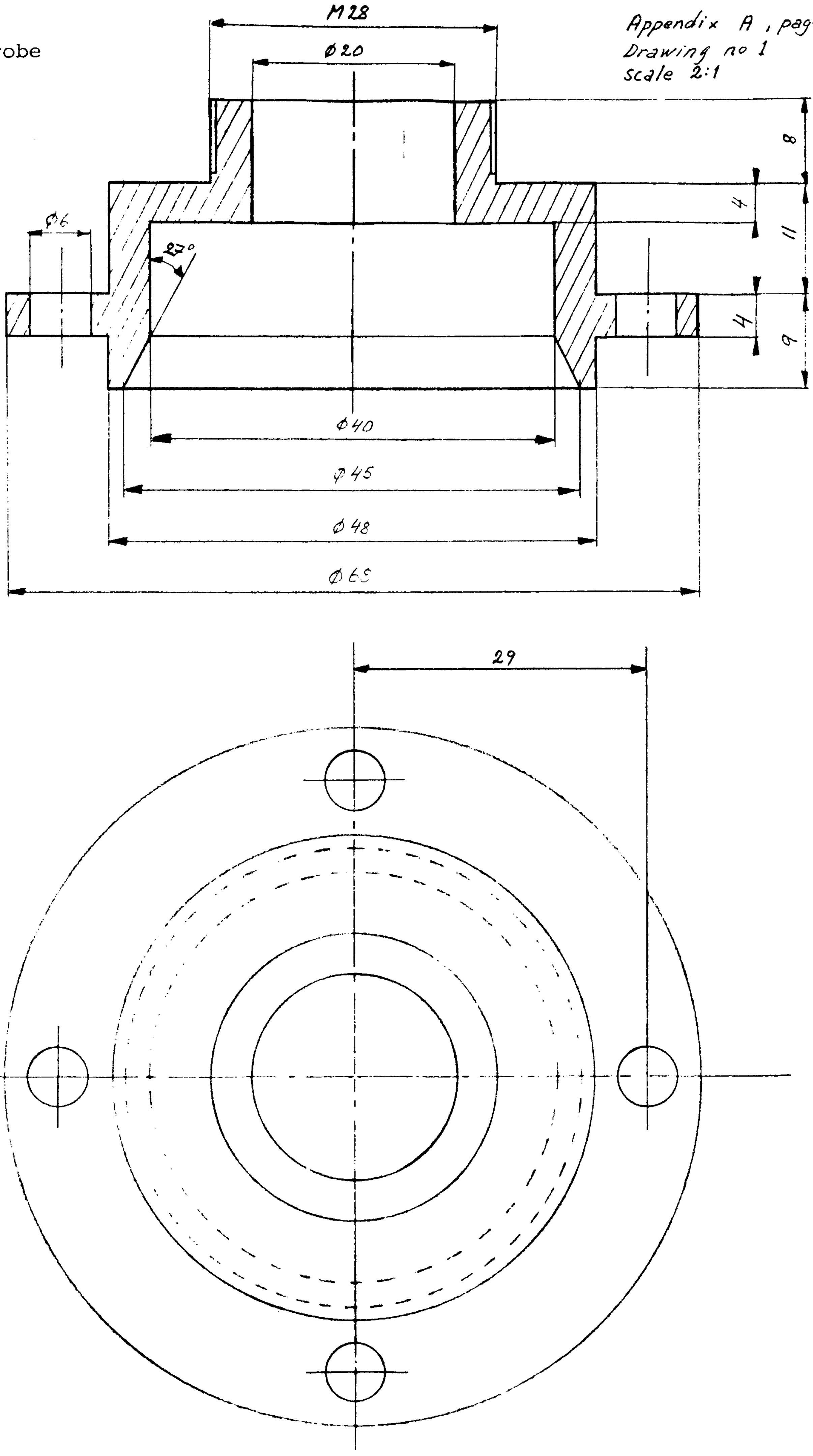
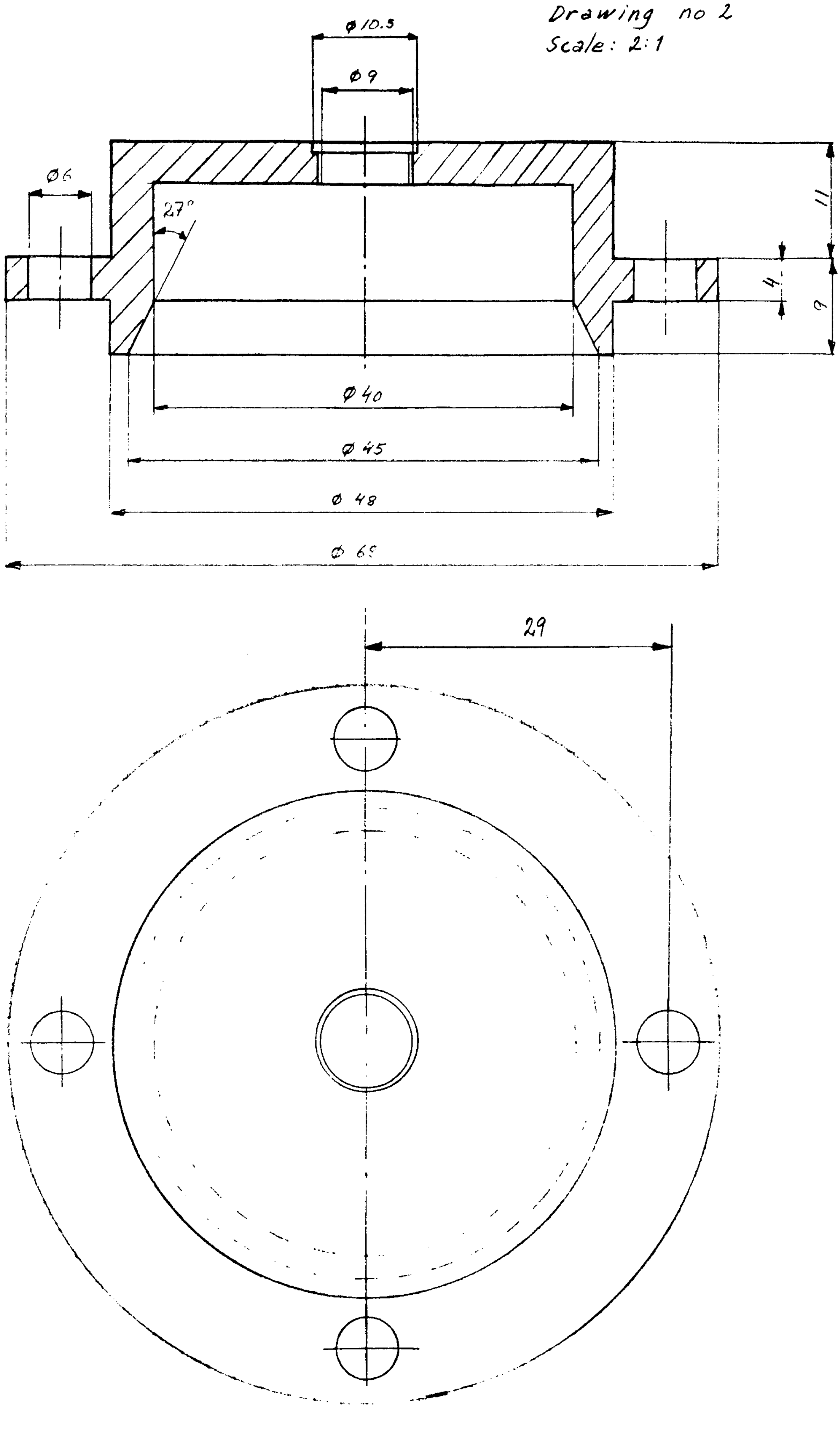
7. APPENDIX

Part of
current probe

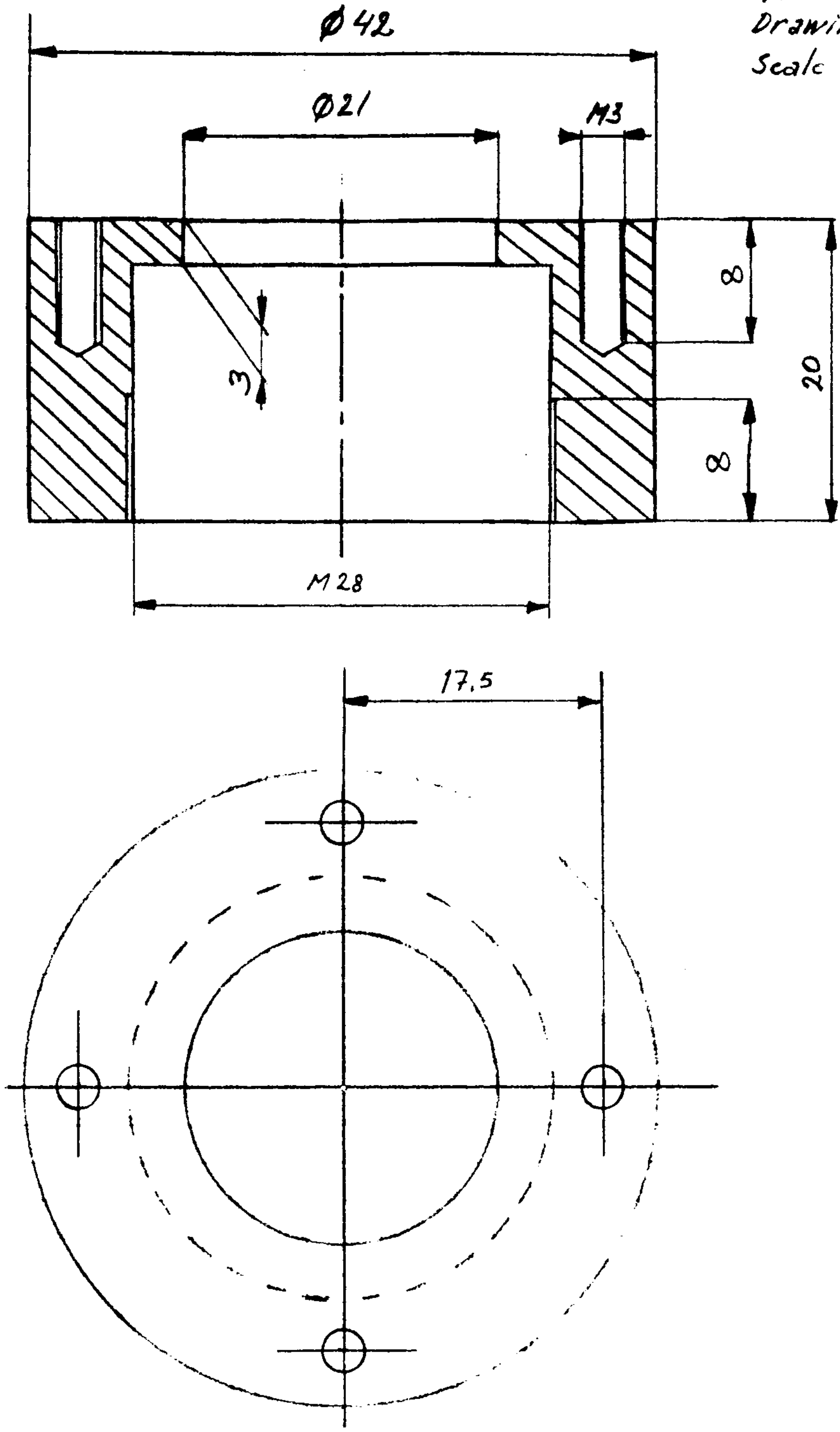
Appendix A, page 1
Drawing no 1
scale 2:1



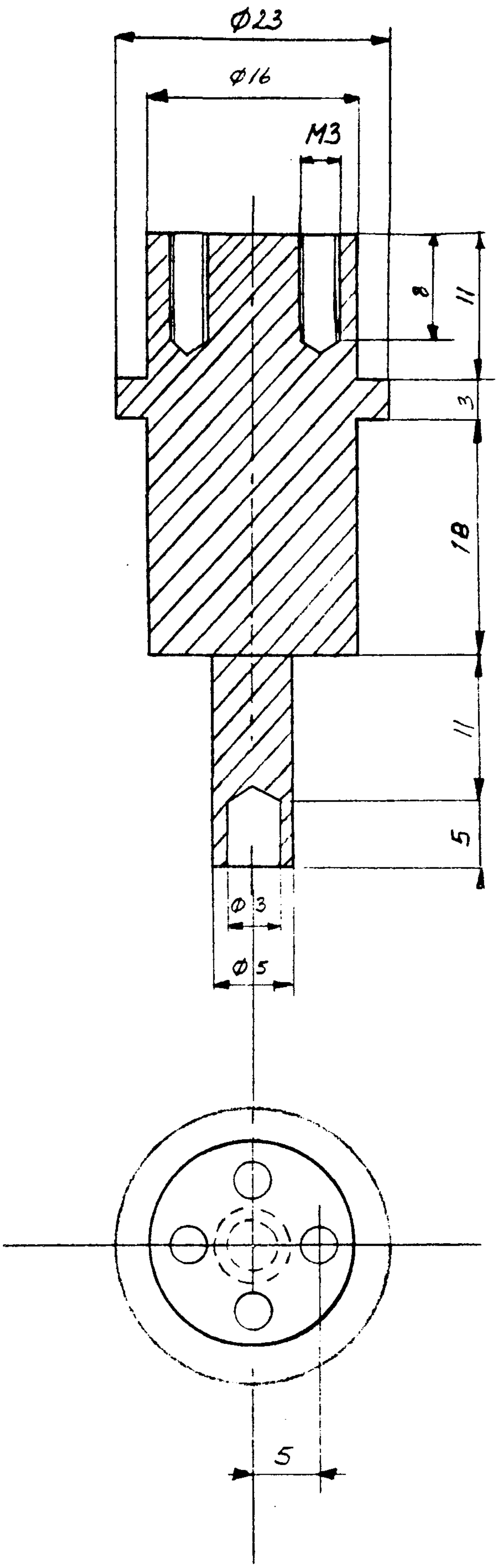
Appendix A, page 2
Drawing no 2
Scale: 2:1



Appendix A, page 3
Drawing no 3
Scale 2:1

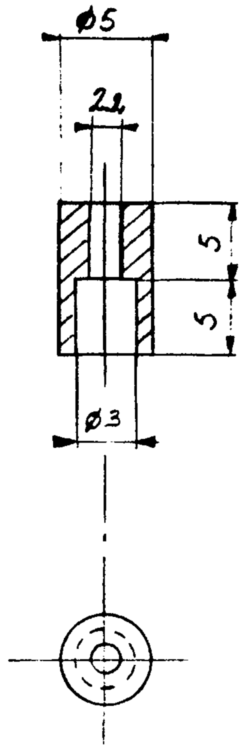


Appendix A, page 4
Drawing no 4
Scale 2:1

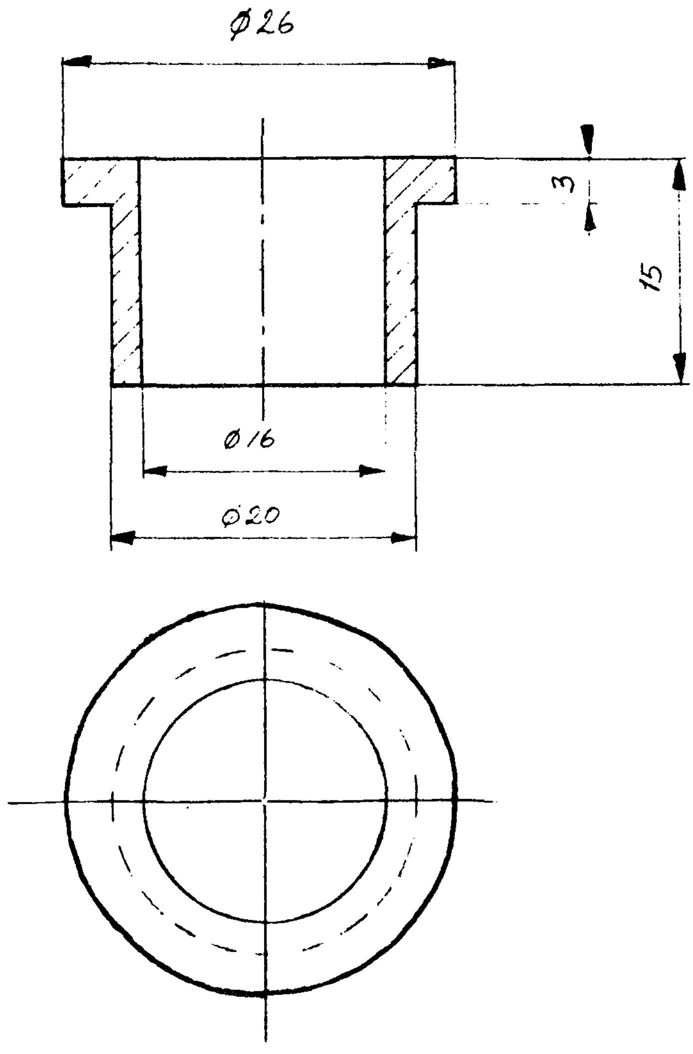


Appendix A, page 5
Drawings no 5, 6
Scale 2:1

5

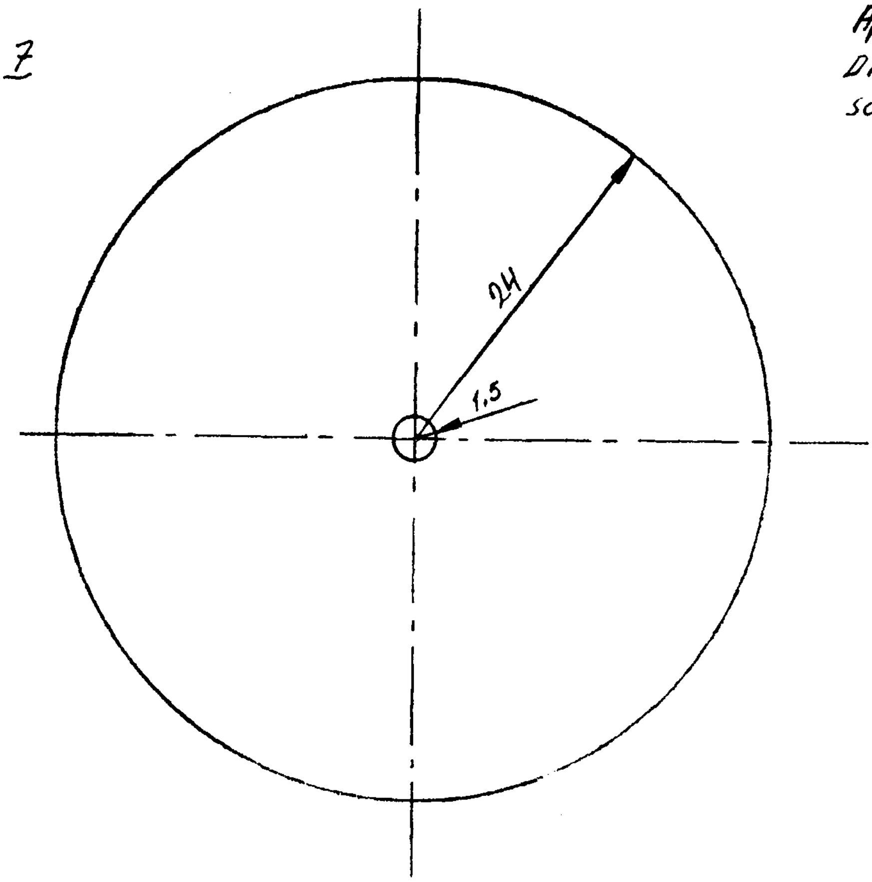


6

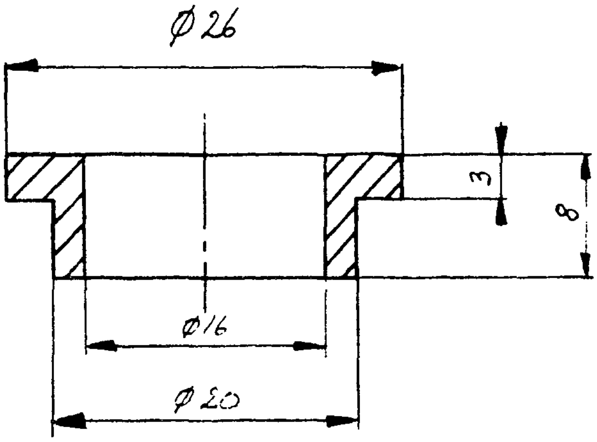


Appendix A, page 6
Drawings 7, 8, 9
scale 2:1

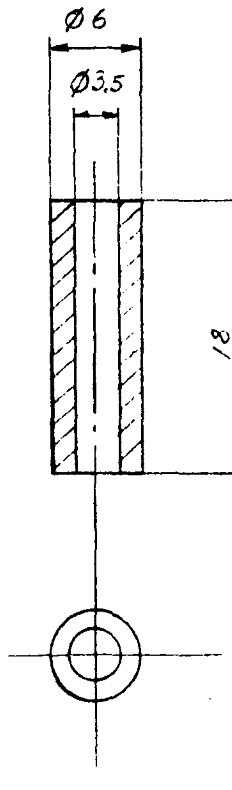
7



8



9



Appendix B side 1

Statens provningsanstalt
Avdelning C
Box 857
501 15 BORÅS
Telefon 033-10 20 00
Telex 36252 testing s

KALIBRERINGSBEVIS

utfärdat av riksmätplats

Nummer	Sido (Sidantal)
01-5382432	1(1)

Ort	Datum
Borås	1982-06-21

Ansvarig för mätplatsen

Gösta Werner
t.f. lab.chef

Ansvarig för mätningen

Lars-Åke Norsten

Riksmätplats utses av regeringen enligt Lag om riksmätplatser m m (SFS 1974:897) och Kungl Maj:ts kungörelse om riksmätplatser m m (SFS 1974:899). Se även bevisets baksida.

Uppdrag nr.: 8232,120

Uppdragsgivare: Tekniska Högskolan i Lund
Inst. Fysik
Box 725
220 07 LUND

Provföremål: 1 st spektral irradiansnormal märkt nummer 2. Lampan är av fabrikat General Electric och har beteckningen DXW 1000 W.

Uppdrag: Absolut spektral kalibrering av irradiansen från 250 nm till 1600 nm på ett avstånd av 0,500 m, mätt till centrum av den spiral glödtråden bildar.

Förutsättningar: Lampan monteras med beteckningen 1000 W, 120 V uppåt i hållaren och med glaskolvens "pip" till höger i strålriktningen. Lampan matas med likström, 7,900 A och med positiv polaritet på lamphållarens toppanslutning.

Metod: En bariumsulfattablett (integrerande sfär i området 400-800 nm) bestrålades dels från mätobjektet dels från en spektral irradiansnormal (F-29) kalibrerad vid National Bureau of Standards, USA. Tabletten var placerad framför ingångsspalten hos en monokromator, Zeiss MM12 och nivåerna jämfördes i våglängdsområdet 250-1600 nm.

Mätresultat: I tabell 1 redovisas absolutnivåerna i W/cm^3 ($mW/m^2/nm$). Onoggrannheten i våglängdsintervallet 250-400 nm är ± 5%, och från 400-1600 nm ± 3%.

RMP 01

Appendix B side 2

Wavel nm	Sp irr Wcm-3	Wavel nm	Sp irr Wcm-3
250	0.166	620	158
255	0.219	630	164
260	0.290	640	170
265	0.390	650	176
270	0.503	660	182
275	0.641	670	188
280	0.778	680	193
285	1.00	690	198
290	1.23	700	203
295	1.49	710	208
300	1.78	720	212
305	2.13	730	216
310	2.54	740	219
315	3.00	750	223
320	3.53	760	226
325	4.10	770	229
330	4.75	780	232
335	5.45	790	234
340	6.22	800	237
345	7.07	825	241
350	8.00	850	246
355	8.99	875	250
360	10.1	900	253
365	11.3	925	253
370	12.5	950	253
375	13.9	975	252
380	15.4	1000	250
385	16.9	1025	247
390	18.5	1050	245
395	20.4	1075	241
400	22.1	1100	238
410	26.0	1125	234
420	30.2	1150	230
430	34.9	1175	225
440	39.8	1200	220
450	45.2	1225	214
460	50.8	1250	209
470	56.6	1275	203
480	62.6	1300	198
490	68.9	1325	192
500	75.3	1350	186
510	82.1	1375	180
520	88.9	1400	174
530	95.7	1425	168
540	103	1450	163
550	110	1475	157
560	117	1500	152
570	124	1525	147
580	131	1550	143
590	138	1575	138
600	145	1600	134
610	151		

Appendix C, sida 1

```
      PROGRAM SPECOR
C
C     PROGRAMMET KORRIGERAR SPEKTRUM FRÅN TRACOR NORTHERN MÅNGKANAL
C     ANALYSATOR MED TILLHÖRANDE DIODARRAY OCH MONOKROMATOR.
C
      BYTE FILNAMN(14),LINE(64),NAMN(6),LINE1(64),LINE2(64),LINE3(64),
     &ANSWER
      DIMENSION XAXE(128),YAXE1(1024),YAXE2(1024)
      INTEGER NUMB,K1,N1,N2,K
      COMMON YAXE1
C     INTEGER*4 YAXE2(1024)
      ANSWER='Y'
C
    1 TYPE*,
      TYPE*,'WHAT KIND OF FILE MANIPULATION DO YOU WANT TO DO?'
      TYPE*,'1) SPECTRUM CORRECTION'
      TYPE*,'2) SPECTRUM DIVISION (WHEN DOUBLE SLIT HAS BEEN USED)'
      TYPE*,'ANSWER (1/2)'
      ACCEPT 100,NUMB
      IF(NUMB.NE.1.AND.NUMB.NE.2) GO TO 1
      GO TO 2
  993 TYPE*,
      TYPE*,'FILE DO NOT EXIST ON DRIVE DY1:(TRY ANOTHER NAME!)'
    2 TYPE*,
      TYPE*,'WRITE THE NAME OF THE FILE YOU WANT TO MANIPULATE'
      TYPE*,'FILE MUST BE ON DRIVE DY1 AND OF TYPE TND'
      TYPE*,'MAXIMUM FIVE LETTERS IN FILENAME'
      ACCEPT 200,NAMN
      FILNAMN(1)='D'
      FILNAMN(2)='Y'
      FILNAMN(3)='1'
      FILNAMN(4)=':'
C
      DO 3 I=5,10
      K1=I
      IF(NAMN(I-4).EQ.' ') GO TO 4
      FILNAMN(I)=NAMN(I-4)
    3 CONTINUE
C
      K1=K1+1
    4 FILNAMN(K1)='.'
      FILNAMN(K1+1)='T'
      FILNAMN(K1+2)='N'
      FILNAMN(K1+3)='D'
      IF(K1+3.EQ.14) GO TO 5
C
      DO 6 I=K1+4,14
      FILNAMN(I)=' '
    6 CONTINUE
C
    5 OPEN(UNIT=3,NAME=FILNAMN,ERR=993,TYPE='OLD')
      READ(3,300) LINE
      READ(3,300) LINE1
      READ(3,300) LINE2
      READ(3,300) LINE3
C
      DO 7 K=1,128
      N2=8*K
      N1=N2-7
      READ(3,300,END=997) LINE
      DECODE(64,400,LINE,ERR=995) XAXE(K),(YAXE1(I),I=N1,N2)
    7 CONTINUE
C
      CLOSE(UNIT=3)
C
C     SUBRUTINHOPP
      IF(NUMB.EQ.1) CALL SPC
      IF(NUMB.EQ.2) CALL SPD
C
      DO 9 I=1,1024
      YAXE2(I)=AINT(YAXE1(I))
    9 CONTINUE
```

```
C     PROGRAMMET KORRIGERAR SPEKTRUM FRAN TRACOR NORTHERN MANGKANAL
C     ANALYSATOR MED TILLHÖRANDE DIODARRAY OCH MONOKROMATOR.
C
      BYTE FILNAMN(14),LINE(64),NAMN(6),LINE1(64),LINE2(64),LINE3(64),
     &ANSWER
      DIMENSION XAXE(128),YAXE1(1024),YAXE2(1024)
      INTEGER NUMB,K1,N1,N2,K
      COMMON YAXE1
C     INTEGER*4 YAXE2(1024)
      ANSWER='Y'
C
    1 TYPE*,
      TYPE*,'WHAT KIND OF FILE MANIPULATION DO YOU WANT TO DO?'
      TYPE*,'1) SPECTRUM CORRECTION'
      TYPE*,'2) SPECTRUM DIVISION (WHEN DOUBLE SLIT HAS BEEN USED)'
      TYPE*,'ANSWER (1/2)'
      ACCEPT 100,NUMB
      IF(NUMB.NE.1.AND.NUMB.NE.2) GO TO 1
      GO TO 2
  993 TYPE*,
      TYPE*,'FILE DO NOT EXIST ON DRIVE DY1:(TRY ANOTHER NAME!)'
    2 TYPE*,
      TYPE*,'WRITE THE NAME OF THE FILE YOU WANT TO MANIPULATE'
      TYPE*,'FILE MUST BE ON DRIVE DY1 AND OF TYPE TND'
      TYPE*,'MAXIMUM FIVE LETTERS IN FILENAME'
      ACCEPT 200,NAMN
      FILNAMN(1)='D'
      FILNAMN(2)='Y'
      FILNAMN(3)='1'
      FILNAMN(4)=':'
C
      DO 3 I=5,10
      K1=I
      IF(NAMN(I-4).EQ.' ') GO TO 4
      FILNAMN(I)=NAMN(I-4)
    3 CONTINUE
C
      K1=K1+1
    4 FILNAMN(K1)='.'
      FILNAMN(K1+1)='T'
      FILNAMN(K1+2)='N'
      FILNAMN(K1+3)='D'
      IF(K1+3.EQ.14) GO TO 5
C
      DO 6 I=K1+4,14
      FILNAMN(I)=' '
    6 CONTINUE
C
    5 OPEN(UNIT=3,NAME=FILNAMN,ERR=993,TYPE='OLD')
      READ(3,300) LINE
      READ(3,300) LINE1
      READ(3,300) LINE2
      READ(3,300) LINE3
C
      DO 7 K=1,128
      N2=8*K
      N1=N2-7
      READ(3,300,END=997) LINE
      DECODE(64,400,LINE,ERR=995) XAXE(K),(YAXE1(I),I=N1,N2)
    7 CONTINUE
C
      CLOSE(UNIT=3)
C
C     SUBRUTINHOPP
      IF(NUMB.EQ.1) CALL SPC
      IF(NUMB.EQ.2) CALL SPD
C
      DO 9 I=1,1024
      YAXE2(I)=AINT(YAXE1(I))
```

```
      CONTINUE
C
C     UTSKRIFT PÅ NY FIL
      TYPE*,
      TYPE*,'PLEASE GIVE A NEW NAME FOR THE OUTPUT FILE'
      TYPE*,'MAXIMUM FIVE LETTERS IN FILENAME'
      TYPE*,'FILE NAME WILL BE FOLLOWED BY .TND IN FILE CATALOGUE'
      ACCEPT 200,NAMN
C
      DO 10 I=5,10
      K1=I
      IF(NAMN(I-4).EQ.' ') GO TO 11
      FILNAMN(I)=NAMN(I-4)
   10 CONTINUE
C
      K1=K1+1
   11 FILNAMN(K1)='.'
      FILNAMN(K1+1)='T'
      FILNAMN(K1+2)='N'
      FILNAMN(K1+3)='D'
      IF(K1+3.EQ.14) GO TO 12
C
      DO 13 I=K1+4,14
      FILNAMN(I)=' '
   13 CONTINUE
C
   12 OPEN(UNIT=2,ERR=991,NAME=FILNAMN,TYPE='NEW')
   18 TYPE*,
      TYPE*,'DO YOU WANT TO PUT A TEXT-LABLE ON YOUR NEW CURVE?(Y/N)'
      ACCEPT 500,ANSWER
      IF(ANSWER.EQ.'N') GO TO 14
      IF(ANSWER.EQ.'Y') GO TO 17
      GO TO 18
   17 TYPE*,
      TYPE*,'WRITE YOUR LABLE (MAX 64 LETTERS)'
      ACCEPT 300,LINE1
C
   14 WRITE(2,700) LINE1
      WRITE(2,700) LINE1
      WRITE(2,700) LINE2
      WRITE(2,700) LINE3
C
      DO 15 K=1,128
      N2=8*K
      N1=N2-7
      ENCODE(64,600,LINE,ERR=989) XAXE(K),(YAXE2(I),I=N1,N2)
         DO 16 I=14,63,7
         LINE(I)=' '
   16    CONTINUE
      WRITE(2,700) LINE
   15 CONTINUE
C
      GO TO 999
C
C     FELMEDDELANDEN MM
  997 TYPE*,'FILE END TOO SOON (SHORTER THAN 1024 POINTS)'
      GO TO 999
  995 TYPE*,'DECODING ERROR'
      TYPE*,'SEE IF FILE VALUES ARE CORRECTLY ARRANGED'
      GO TO 999
  991 TYPE*,'SAVING FILE CAN NOT BE OPENED'
      GO TO 999
  989 TYPE*,'IT IS NOT POSSIBLE TO ENCODE YOUR NEW DATA'
  999 CLOSE(UNIT=2)
C
  100 FORMAT(I1)
  200 FORMAT(6A1)
  300 FORMAT(64A1)
  400 FORMAT(9F7.0)
  500 FORMAT(A1)
  600 FORMAT(F7.1,8F7.0)
  700 FORMAT(' ',64A1)
C
```

```
      STOP
      END
C
C
C
C
C
C
C
C
C
      SUBROUTINE SPC
C
      COMMON YAXE1
      DIMENSION YAXE1(1024),CF(103),DIODF(1024)
      INTEGER CHNR,CL,CH,WAVEL(103),W1,W2,LAMB1,LAMB2,I,J,K,NSPNR,A,B,
     &NCH,IWL1,SCALE
      REAL WPCH,IWL,TNMAX
C
    3 TYPE*,
      TYPE*,'WHAT TYPE OF MONOCHROMATOR HAS BEEN USED?'
      TYPE*,'1) SMALL MONOCHROMATOR'
      TYPE*,'2) MEDIUM MONOCHROMATOR'
      TYPE*,'3) 2M EBERT SPECTROGRAPH'
      TYPE*,'ANSWER(1/2/3)'
      ACCEPT 100,MNR
      IF(MNR.GT.3.OR.MNR.LT.1) GO TO 3
C
   30 TYPE*,
      TYPE*,'DO THE 1024 CHANNELS CONTAIN ONE OR TWO SPECTRA?'
      TYPE*,'(ANSWER 1/2)'
      ACCEPT 100,NSPNR
      IF(NSPNR.EQ.1.OR.NSPNR.EQ.2) GO TO 2
      GO TO 30
C
    2 GO TO (1,40,40) MNR
      GO TO 3
C
C     LILLA MONOKROMATORN
    1 OPEN(UNIT=3,NAME='MONOC1',ERR=994,TYPE='OLD')
      GO TO 50
C
C     MELLANMONOKROMATORN OCH 2M EBERT SPEKTROGRAF
   40 TYPE*,
      TYPE*,'FROM WHAT REGION IS YOUR SPECTRUM?'
      TYPE*,'1) INFRARED        (768NM)'
      TYPE*,'2) VISIBLE         (525NM)'
      TYPE*,'3) ULTRAVIOLET     (348NM)'
      TYPE*,'ANSWER (1/2/3)'
      ACCEPT 100,NREG
      IF(NREG.GT.3.OR.NREG.LT.1) GO TO 40
C
      GO TO (61,62,63) NREG
      GO TO 40
   61 OPEN(UNIT=3,NAME='IRKOMP',ERR=994,TYPE='OLD')
      GO TO 50
   62 OPEN(UNIT=3,NAME='VIKOMP',ERR=994,TYPE='OLD')
      GO TO 50
   63 OPEN(UNIT=3,NAME='UVKOMP',ERR=994,TYPE='OLD')
C
   50 READ(3,700) DIODF
      CLOSE(UNIT=3)
C
      DO 51 I=1,512
      K=NSPNR*(I-1)+1
      YAXE1(I)=YAXE1(I)*DIODF(K)
   51 CONTINUE
C
      DO 52 I=513,1024
      K=NSPNR*(I-1-(NSPNR-1)*512)+1
      YAXE1(I)=YAXE1(I)*DIODF(K)
   52 CONTINUE
```

```
      CONTINUE
C
C       OVERFLOW TEST
   32 TNMAX=1.0
      YAXE1(1)=10.
      YAXE1(2)=10.
      YAXE1(3)=10.
      YAXE1(4)=10.
      YAXE1(1021)=10.
      YAXE1(1022)=10.
      YAXE1(1023)=10.
      YAXE1(1024)=10.
      IF(NSPNR.EQ.1) GO TO 33
      YAXE1(511)=10.
      YAXE1(512)=10.
      YAXE1(513)=10.
      YAXE1(514)=10.
C
   33 DO 24 L=1,1024
      TNMAX=AMAX1(TNMAX,YAXE1(L))
   24 CONTINUE
C
      IF(TNMAX.GT.999999.) GO TO 25
      GO TO 26
   25 TYPE*,
      TYPE*,'WARNING: VALUES EXCEED 1,000,000 WHICH CAN NOT BE '
      TYPE*,'ACCEPTED BY TRACOR NORTHERN ANALYZER'
      TYPE*,'AUTOMATIC SCALING WILL BE PERFORMED'
      SCALE=TNMAX/950000.
C
      DO 27 I=1,1024
      YAXE1(I)=YAXE1(I)/SCALE
   27 CONTINUE
C
      GO TO 26
  994 TYPE*,
      TYPE*,'READING ERROR'
      STOP
C
  100 FORMAT(I1)
  200 FORMAT(1X,'CHANNEL NO  ',I4,'  CORRESPONDS TO')
  300 FORMAT(A1)
  400 FORMAT(I4)
  500 FORMAT(1X,'VALUES FOR CL,CH,LAMB1,LAMB2 ARE',//,1X,4I7)
  600 FORMAT(I4)
  700 FORMAT(F10.4)
  800 FORMAT(1X,'WAVELENGTH  ',I4)
C
   26 RETURN
      END
C
C
C
C
C
C
C
C
C
C
      SUBROUTINE SPD
C
      COMMON YAXE1
      DIMENSION YAXE1(1024)
      INTEGER CHNL1,CHNL2,CHNL3,CHNL4,IA,NCH
      REAL FACT,TNMAX,SCALE
C
   10 IA=0
      TYPE*,
      TYPE*,'WHICH CHANNELS DO YOU WANT TO DIVIDE?'
      TYPE*,'THE CHANNELS SHOULD BE GIVEN IN TWO GROUPS,'
      TYPE*,'WERE THE CHANNELS IN THE SECOND GROUP WILL BE'
      TYPE*,'DIVIDED WITH THE CHANNELS IN THE FIRST GROUP.'
```

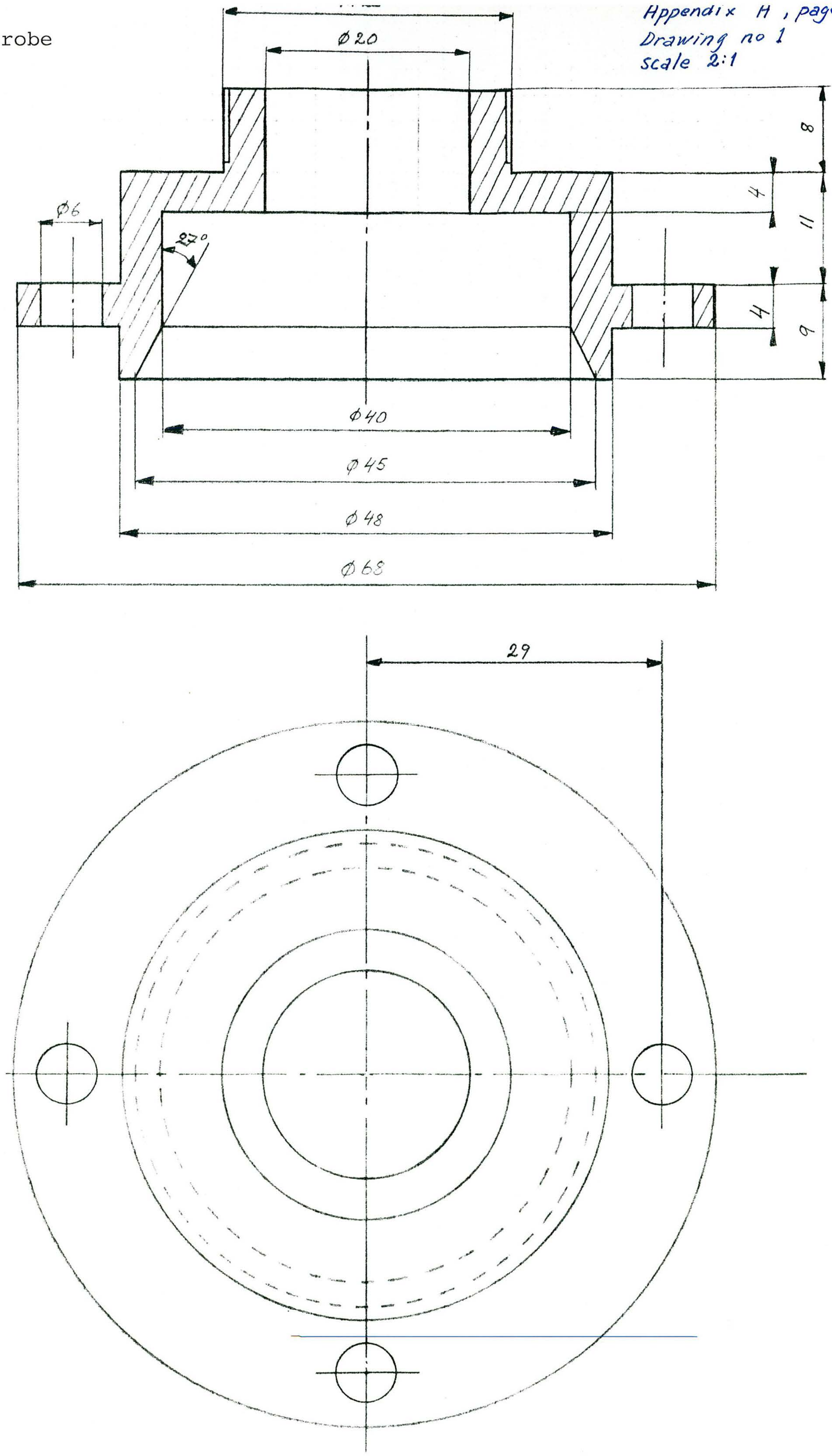
```
      TYPE*,'DIVIDED WITH THE CHANNELS IN THE FIRST GROUP.'
      TYPE*,'CHNL1 REFERS TO THE LOWEST CHANNEL NO IN THE'
      TYPE*,'FIRST GROUP, AND CHNL2 REFERS TO THE HIGHEST ONE.'
      TYPE*,'SIMILAR ORDER FOR CHNL3 AND CHNL4 IN THE 2:ND GROUP.'
      TYPE*,
      TYPE*,'BOTH GROUPS MUST CONTAIN THE SAME NUMBER OF CHANNELS'
      TYPE*,
      TYPE*,'THE RESULT CAN BE FOUND IN CHANNELS CHNL3-CHNL4'
      TYPE*,'OBSERVE THAT OTHER VALUES THAN THOSE IN'
      TYPE*,'CHNL3-CHNL4 MAY BE CHANGED DURING CALCULATIONS'
      TYPE*,
    4 TYPE*,'CHNL1='
      ACCEPT 100,CHNL1
      IF(IA.EQ.1) GO TO 8
    5 TYPE*,'CHNL2='
      ACCEPT 100,CHNL2
      IF(IA.EQ.1) GO TO 8
    6 TYPE*,'CHNL3='
      ACCEPT 100,CHNL3
      IF(IA.EQ.1)GO TO 8
    7 TYPE*,'CHNL4='
      ACCEPT 100,CHNL4
C
    8 IA=0
      TYPE*,
      WRITE(7,200) CHNL1,CHNL2,CHNL3,CHNL4
    1 TYPE*,
      TYPE*,'DO YOU WANT TO CHANGE ANYONE OF THESE?(Y/N)'
      ACCEPT 300,ANSWER
      IF(ANSWER.EQ.'Y') GO TO 2
      IF(ANSWER.EQ.'N') GO TO 3
      GO TO 1
C
    2 IA=1
      TYPE*,
      TYPE*,'WHICH CHANNEL NO DO YOU WANT TO CHANGE?(1/2/3/4)'
      ACCEPT 400,NCH
      GO TO (4,5,6,7) NCH
      GO TO 2
C
C     INDATA TEST
    3 IF(CHNL2-CHNL1.NE.CHNL4-CHNL3) GO TO 30
      IF(CHNL1.LT.1.OR.CHNL1.GT.1024) GO TO 30
      IF(CHNL2.LT.1.OR.CHNL2.GT.1024) GO TO 30
      IF(CHNL3.LT.1.OR.CHNL3.GT.1024) GO TO 30
      IF(CHNL4.LT.1.OR.CHNL4.GT.1024) GO TO 30
      GO TO 15
   30 TYPE*,
      TYPE*,'ERROR IN INPUT DATA, YOU MUST REPEAT THE INPUT PROCEDURE'
      TYPE*,
      GO TO 10
C
   15 TYPE*,
      TYPE*,'DO YOU WANT TO MULTIPLY THE VALUES BELONGING TO'
      TYPE*,'CHNL1-CHNL2 WITH A FACTOR?(Y/N)'
      ACCEPT 300,ANSWER
      IF(ANSWER.EQ.'Y') GO TO 16
      IF(ANSWER.EQ.'N') GO TO 17
      GO TO 15
   16 TYPE*,
      TYPE*,'GIVE THE FACTOR PLEASE (F-FORMAT F12.5)'
      ACCEPT 500,FACT
      TYPE*,
      WRITE(7,600) FACT
      TYPE*,
      TYPE*,'DO YOU WANT TO CHANGE IT?(Y/N)'
      ACCEPT 300,ANSWER
      IF(ANSWER.EQ.'N') GO TO 18
      GO TO 16
C
   18 DO 19 I=CHNL1,CHNL2
      YAXE1(I)=YAXE1(I)*FACT
   19 CONTINUE
```

```
   19 CONTINUE
C
   17 K=CHNL1
C
      DO 20 I=CHNL3,CHNL4
      IF(YAXE1(I).EQ.0.) YAXE1(I)=1.0
      IF(YAXE1(K).EQ.0.) YAXE1(K)=1.0
      YAXE1(I)=YAXE1(I)/YAXE1(K)
      K=K+1
   20 CONTINUE
C
C     OVERFLOW-TEST
      TNMAX=1.0
C
      DO 21 I=1,1024
      TNMAX=AMAX1(TNMAX,YAXE1(I))
   21 CONTINUE
C
      IF(TNMAX.GT.999999.) GO TO 22
      GO TO 24
   22 TYPE*,
      TYPE*,'WARNING: VALUES EXCEED 1,000,000 WHICH CAN NOT BE ACCEPTED'
      TYPE*,'BY TRACOR NORTHERN ANALYZER'
      TYPE*,'AUTOMATIC SCALING WILL BE PERFORMED'
      SCALE=TNMAX/950000.
C
   23 DO 24 I=1,1024
      YAXE1(I)=YAXE1(I)/SCALE
   24 CONTINUE
C
C
  100 FORMAT(I4)
  200 FORMAT(1X,'GIVEN VALUES FOR CHNL1-CHNL4 ARE',//1X,4I6)
  300 FORMAT(A1)
  400 FORMAT(I1)
  500 FORMAT(F12.5)
  600 FORMAT(1X,'GIVEN MULTIPLICATION FACTOR IS',//1X,F12.5)
C
      RETURN
      END
```

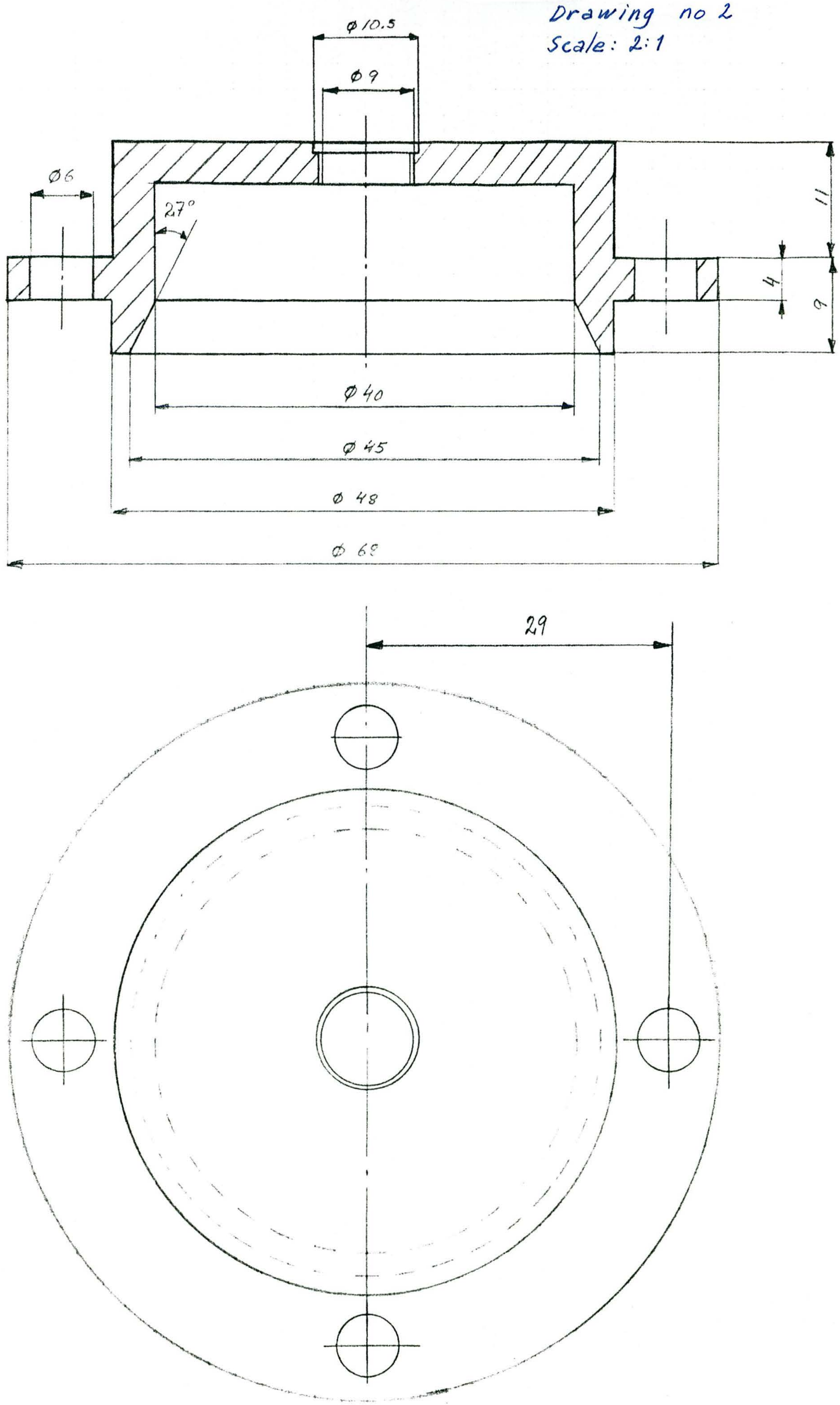
```
      PROGRAM DNORM
      DIMENSION XAXE(128),YAXE1(1024)
      BYTE LINE(64)
C
      OPEN(UNIT=3,NAME='IRKOM.TND',ERR=1000,TYPE='OLD')
      READ(3,100) LINE
      READ(3,100) LINE
      READ(3,100) LINE
      READ(3,100) LINE
C
      DO 1 K=1,128
      N2=8*K
      N1=N2-7
      READ(3,100,END=1000) LINE
      DECODE(64,200,LINE,ERR=1000) XAXE(K),(YAXE1(I),I=N1,N2)
    1 CONTINUE
C
      CLOSE(UNIT=3)
      SUM=0.
C
      DO 2 L=1,1024
      SUM=SUM+YAXE1(L)
    2 CONTINUE
C
      DO 3 M=1,1024
      IF(YAXE1(M).LT.1.) YAXE1(M)=1.0
      YAXE1(M)=YAXE1(M)*1024./SUM
    3 CONTINUE
C
      OPEN(UNIT=3,NAME='IRKOMP',ERR=1000,TYPE='UNKNOWN')
C
      DO 4 N=1,1024
      DIODF=10./YAXE1(N)
      WRITE(3,300) DIODF
    4 CONTINUE
C
      CLOSE(UNIT=3)
      GO TO 5
C
  100 FORMAT(64A1)
  200 FORMAT(9F7.0)
  300 FORMAT(F10.4)
C
 1000 TYPE*,'FEL NAGONSTANS'
C
    5 STOP
      END
```

Part of
current probe

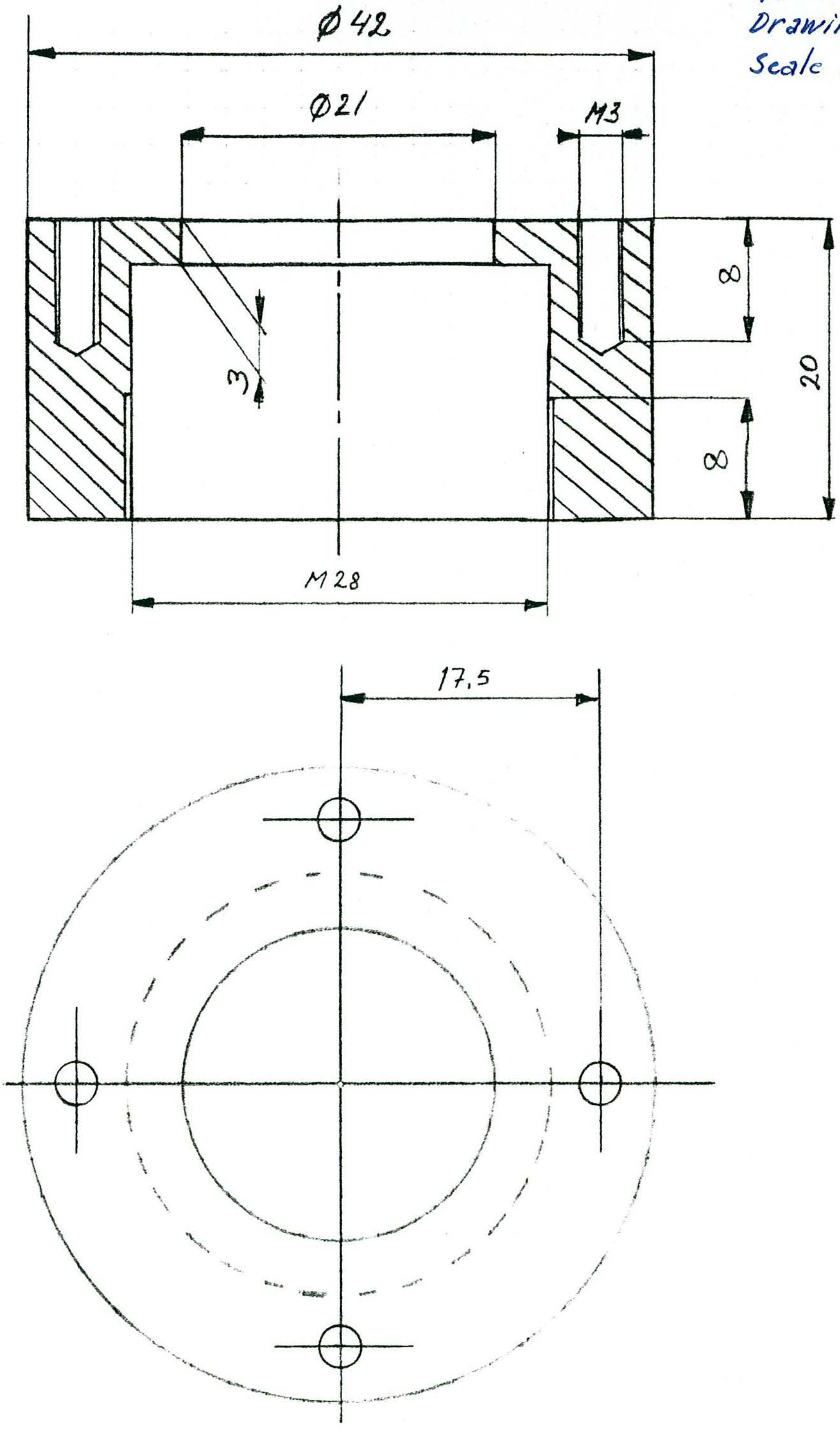
Appendix A, page 1
Drawing no 1
scale 2:1



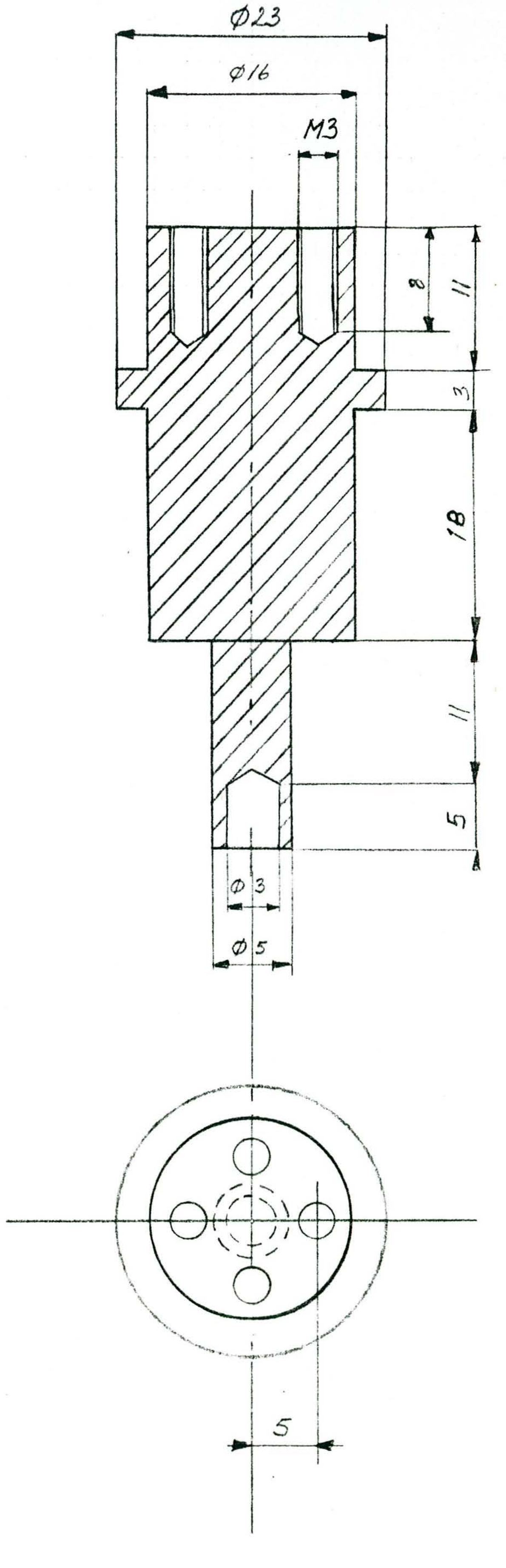
Appendix H, page 2
Drawing no 2
Scale: 2:1



Appendix A, page 3
Drawing no 3
Scale 2:1

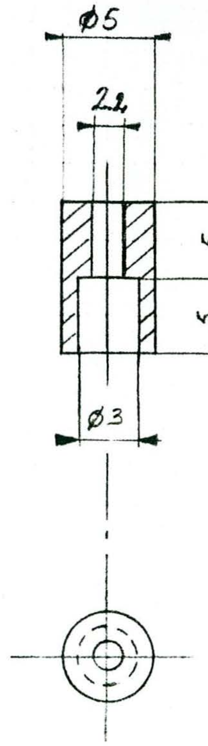


Appendix A, page 4
Drawing no 4
Scale 2:1

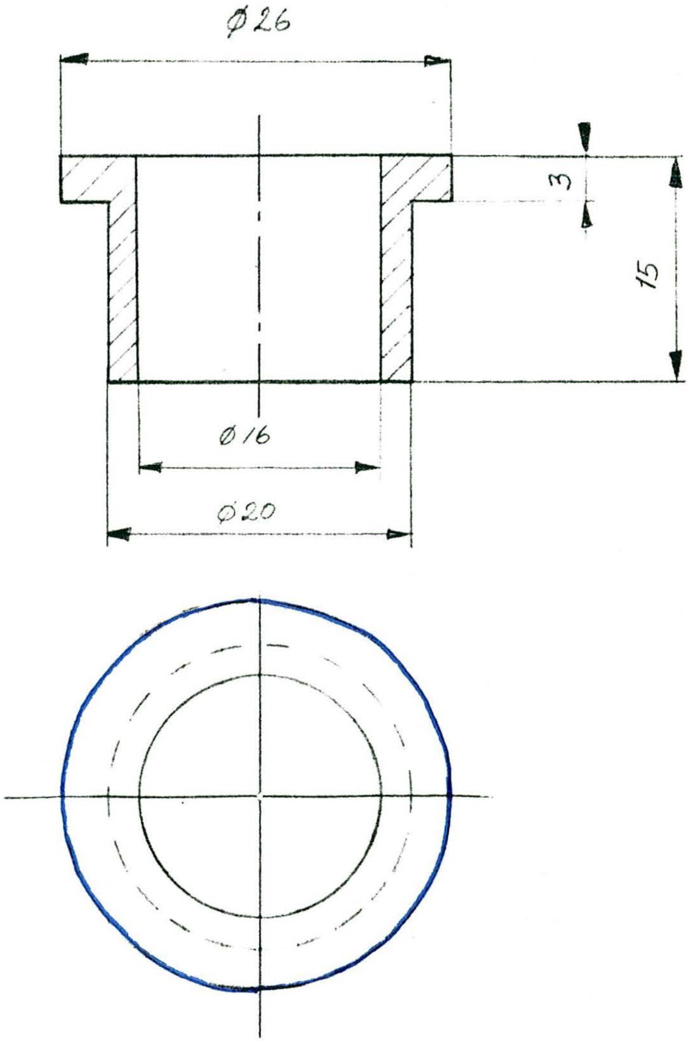


Appendix A, page 5
Drawings no 5, 6
Scale 2:1

5

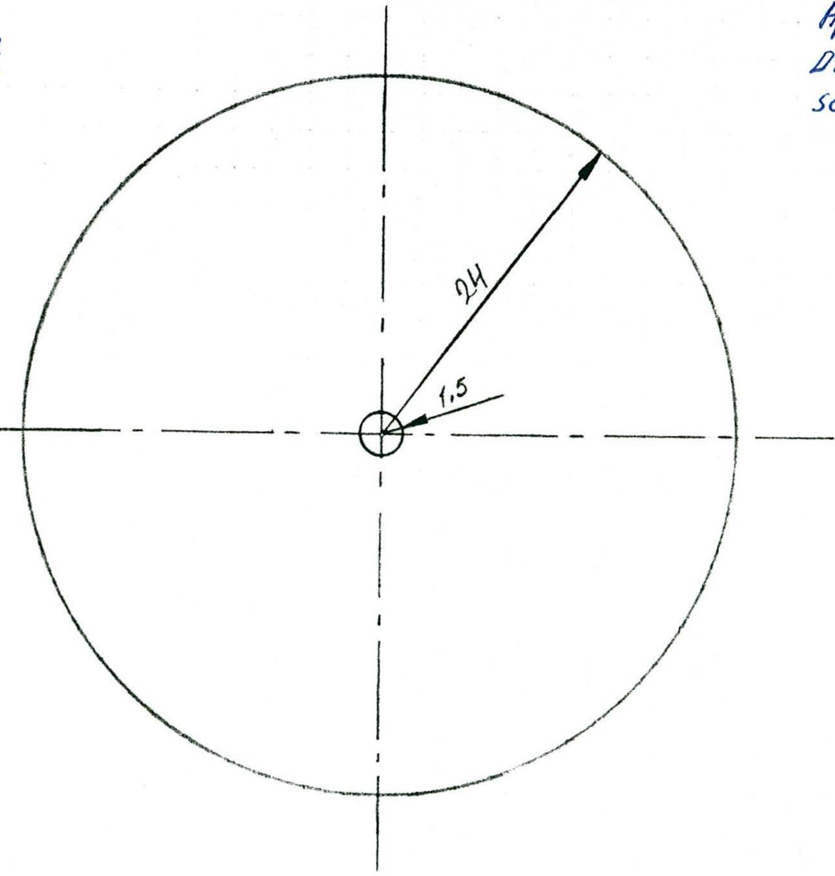


6

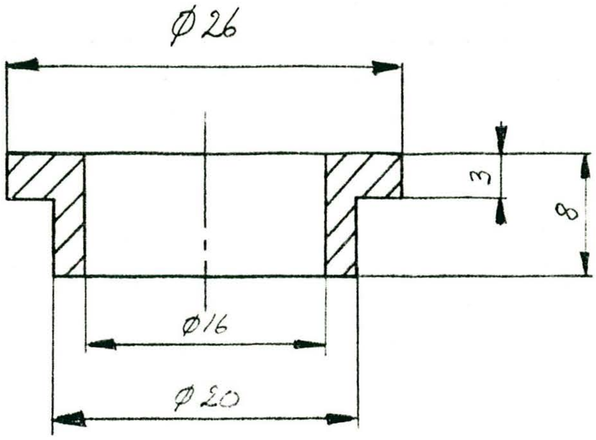


Appendix A, page 6
Drawings 7, 8, 9
Scale 2:1

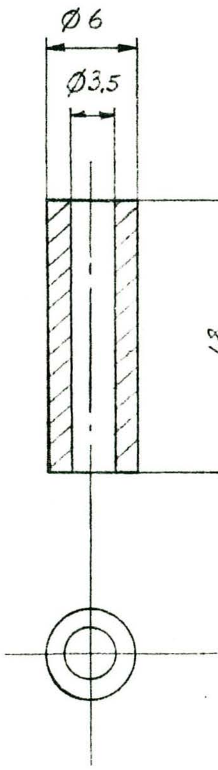
7



8



9



Statens provningsanstalt
Avdelning C

Box 857
501 15 BORÅS
Telefon 033-10 20 00
Telex 36252 testing s

KALIBRERINGSBEVIS

utfärdat av riksmätplats

Nummer	Sido (Sidantal)
01-5382432	1(1)

Ort	Datum
Borås	1982-06-21

Ansvarig för mätplatsen
Gösta Werner
t.f. lab.chef

Ansvarig för mätningen
Lars-Åke Norsten

Riksmätplats utses av regeringen enligt Lag om riksmätplatser m m (SFS 1974:897) och Kungl Maj:ts kungörelse om riksmätplatser m m (SFS 1974:899). Se även bevisets baksida.

Uppdrag nr.: 8232,120

Uppdragsgivare: Tekniska Högskolan i Lund
Inst. Fysik
Box 725
220 07 LUND

Provföremål: 1 st spektral irradiansnormal märkt nummer 2. Lampan är av fabrikat General Electric och har beteckningen DXW 1000 W.

Uppdrag: Absolut spektral kalibrering av irradiansen från 250 nm till 1600 nm på ett avstånd av 0,500 m, mätt till centrum av den spiral glödtråden bildar.

Förutsättningar: Lampan monteras med beteckningen 1000 W, 120 V uppåt i hållaren och med glaskolvens "pip" till höger i strålriktningen. Lampan matas med likström, 7,900 A och med positiv polaritet på lamphållarens toppanslutning.

Metod: En bariumsulfattablett (integrerande sfär i området 400-800 nm) bestrålades dels från mätobjektet dels från en spektral irradiansnormal (F-29) kalibrerad vid National Bureau of Standards, USA. Tabletten var placerad framför ingångsspalten hos en monokromator, Zeiss MM12 och nivåerna jämfördes i våglängdsområdet 250-1600 nm.

Mätresultat: I tabell 1 redovisas absolutnivåerna i W/cm^3 (mW/m^2/nm). Onoggrannheten i våglängdsintervallet 250-400 nm är ± 5%, och från 400-1600 nm ± 3%.

RMP 01

Wavel nm	Sp irr Wcm-3	Wavel nm	Sp irr Wcm-3
250	0.166	620	158
255	0.219	630	164
260	0.290	640	170
265	0.390	650	176
270	0.503	660	182
275	0.641	670	188
280	0.778	680	193
285	1.00	690	198
290	1.23	700	203
295	1.49	710	208
300	1.78	720	212
305	2.13	730	216
310	2.54	740	219
315	3.00	750	223
320	3.53	760	226
325	4.10	770	229
330	4.75	780	232
335	5.45	790	234
340	6.22	800	237
345	7.07	825	241
350	8.00	850	246
355	8.99	875	250
360	10.1	900	253
365	11.3	925	253
370	12.5	950	253
375	13.9	975	252
380	15.4	1000	250
385	16.9	1025	247
390	18.5	1050	245
395	20.4	1075	241
400	22.1	1100	238
410	26.0	1125	234
420	30.2	1150	230
430	34.9	1175	225
440	39.8	1200	220
450	45.2	1225	214
460	50.8	1250	209
470	56.6	1275	203
480	62.6	1300	198
490	68.9	1325	192
500	75.3	1350	186
510	82.1	1375	180
520	88.9	1400	174
530	95.7	1425	168
540	103	1450	163
550	110	1475	157
560	117	1500	152
570	124	1525	147
580	131	1550	143
590	138	1575	138
600	145	1600	134
610	151		

```
C
C     PROGRAMMET KORRIGERAR SPEKTRUM FRÅN TRACOR NORTHERN MÅNGKANAL
C     ANALYSATOR MED TILLHÖRANDE DIODARRAY OCH MONOKROMATOR.
C
      BYTE FILNAMN(14),LINE(64),NAMN(6),LINE1(64),LINE2(64),LINE3(64),
     &ANSWER
      DIMENSION XAXE(128),YAXE1(1024),YAXE2(1024)
      INTEGER NUMB,K1,N1,N2,K
      COMMON YAXE1
C     INTEGER*4 YAXE2(1024)
      ANSWER='Y'
C
    1 TYPE*,
      TYPE*,'WHAT KIND OF FILE MANIPULATION DO YOU WANT TO DO?'
      TYPE*,'1) SPECTRUM CORRECTION'
      TYPE*,'2) SPECTRUM DIVISION (WHEN DOUBLE SLIT HAS BEEN USED)'
      TYPE*,'ANSWER (1/2)'
      ACCEPT 100,NUMB
      IF(NUMB.NE.1.AND.NUMB.NE.2) GO TO 1
      GO TO 2
  993 TYPE*,
      TYPE*,'FILE DO NOT EXIST ON DRIVE DY1:(TRY ANOTHER NAME!)'
    2 TYPE*,
      TYPE*,'WRITE THE NAME OF THE FILE YOU WANT TO MANIPULATE'
      TYPE*,'FILE MUST BE ON DRIVE DY1 AND OF TYPE TND'
      TYPE*,'MAXIMUM FIVE LETTERS IN FILENAME'
      ACCEPT 200,NAMN
      FILNAMN(1)='D'
      FILNAMN(2)='Y'
      FILNAMN(3)='1'
      FILNAMN(4)=':'
C
      DO 3 I=5,10
      K1=I
      IF(NAMN(I-4).EQ.' ') GO TO 4
      FILNAMN(I)=NAMN(I-4)
    3 CONTINUE
C
      K1=K1+1
    4 FILNAMN(K1)='.'
      FILNAMN(K1+1)='T'
      FILNAMN(K1+2)='N'
      FILNAMN(K1+3)='D'
      IF(K1+3.EQ.14) GO TO 5
C
      DO 6 I=K1+4,14
      FILNAMN(I)=' '
    6 CONTINUE
C
    5 OPEN(UNIT=3,NAME=FILNAMN,ERR=993,TYPE='OLD')
      READ(3,300) LINE
      READ(3,300) LINE1
      READ(3,300) LINE2
      READ(3,300) LINE3
C
      DO 7 K=1,128
      N2=8*K
      N1=N2-7
      READ(3,300,END=997) LINE
      DECODE(64,400,LINE,ERR=995) XAXE(K),(YAXE1(I),I=N1,N2)
    7 CONTINUE
C
      CLOSE(UNIT=3)
C
C     SUBRUTINHOPP
      IF(NUMB.EQ.1) CALL SPC
      IF(NUMB.EQ.2) CALL SPD
C
      DO 9 I=1,1024
      YAXE2(I)=AINT(YAXE1(I))
```

```
C     PROGRAMMET KORRIGERAR SPEKTRUM FRÅN TRACOR NORTHERN MÅNGKANAL
C     ANALYSATOR MED TILLHÖRANDE DIODARRAY OCH MONOKROMATOR.
C
      BYTE FILNAMN(14),LINE(64),NAMN(6),LINE1(64),LINE2(64),LINE3(64),
     &ANSWER
      DIMENSION XAXE(128),YAXE1(1024),YAXE2(1024)
      INTEGER NUMB,K1,N1,N2,K
      COMMON YAXE1
C     INTEGER*4 YAXE2(1024)
      ANSWER='Y'
C
    1 TYPE*,
      TYPE*,'WHAT KIND OF FILE MANIPULATION DO YOU WANT TO DO?'
      TYPE*,'1) SPECTRUM CORRECTION'
      TYPE*,'2) SPECTRUM DIVISION (WHEN DOUBLE SLIT HAS BEEN USED)'
      TYPE*,'ANSWER (1/2)'
      ACCEPT 100,NUMB
      IF(NUMB.NE.1.AND.NUMB.NE.2) GO TO 1
      GO TO 2
  993 TYPE*,
      TYPE*,'FILE DO NOT EXIST ON DRIVE DY1:(TRY ANOTHER NAME!)'
    2 TYPE*,
      TYPE*,'WRITE THE NAME OF THE FILE YOU WANT TO MANIPULATE'
      TYPE*,'FILE MUST BE ON DRIVE DY1 AND OF TYPE TND'
      TYPE*,'MAXIMUM FIVE LETTERS IN FILENAME'
      ACCEPT 200,NAMN
      FILNAMN(1)='D'
      FILNAMN(2)='Y'
      FILNAMN(3)='1'
      FILNAMN(4)=':'
C
      DO 3 I=5,10
      K1=I
      IF(NAMN(I-4).EQ.' ') GO TO 4
      FILNAMN(I)=NAMN(I-4)
    3 CONTINUE
C
      K1=K1+1
    4 FILNAMN(K1)='.'
      FILNAMN(K1+1)='T'
      FILNAMN(K1+2)='N'
      FILNAMN(K1+3)='D'
      IF(K1+3.EQ.14) GO TO 5
C
      DO 6 I=K1+4,14
      FILNAMN(I)=' '
    6 CONTINUE
C
    5 OPEN(UNIT=3,NAME=FILNAMN,ERR=993,TYPE='OLD')
      READ(3,300) LINE
      READ(3,300) LINE1
      READ(3,300) LINE2
      READ(3,300) LINE3
C
      DO 7 K=1,128
      N2=8*K
      N1=N2-7
      READ(3,300,END=997) LINE
      DECODE(64,400,LINE,ERR=995) XAXE(K),(YAXE1(I),I=N1,N2)
    7 CONTINUE
C
      CLOSE(UNIT=3)
C
C     SUBRUTINHOPP
      IF(NUMB.EQ.1) CALL SPC
      IF(NUMB.EQ.2) CALL SPD
C
      DO 9 I=1,1024
      YAXE2(I)=AINT(YAXE1(I))
```

```
C       UTSKRIFT PÅ NY FIL
        TYPE*,
        TYPE*,'PLEASE GIVE A NEW NAME FOR THE OUTPUT FILE'
        TYPE*,'MAXIMUM FIVE LETTERS IN FILENAME'
        TYPE*,'FILE NAME WILL BE FOLLOWED BY .TND IN FILE CATALOGUE'
        ACCEPT 200,NAMN
C
        DO 10 I=5,10
        K1=I
        IF(NAMN(I-4).EQ.' ') GO TO 11
        FILNAMN(I)=NAMN(I-4)
   10   CONTINUE
C
        K1=K1+1
   11   FILNAMN(K1)='.'
        FILNAMN(K1+1)='T'
        FILNAMN(K1+2)='N'
        FILNAMN(K1+3)='D'
        IF(K1+3.EQ.14) GO TO 12
C
        DO 13 I=K1+4,14
        FILNAMN(I)=' '
   13   CONTINUE
C
   12   OPEN(UNIT=2,ERR=991,NAME=FILNAMN,TYPE='NEW')
   18   TYPE*,
        TYPE*,'DO YOU WANT TO PUT A TEXT-LABLE ON YOUR NEW CURVE?(Y/N)'
        ACCEPT 500,ANSWER
        IF(ANSWER.EQ.'N') GO TO 14
        IF(ANSWER.EQ.'Y') GO TO 17
        GO TO 18
   17   TYPE*,
        TYPE*,'WRITE YOUR LABLE (MAX 64 LETTERS)'
        ACCEPT 300,LINE1
C
   14   WRITE(2,700) LINE1
        WRITE(2,700) LINE1
        WRITE(2,700) LINE2
        WRITE(2,700) LINE3
C
        DO 15 K=1,128
        N2=8*K
        N1=N2-7
        ENCODE(64,600,LINE,ERR=989) XAXE(K),(YAXE2(I),I=N1,N2)
           DO 16 I=14,63,7
           LINE(I)=' '
   16      CONTINUE
        WRITE(2,700) LINE
   15   CONTINUE
C
        GO TO 999
C
C       FELMEDDELANDEN MM
  997   TYPE*,'FILE END TOO SOON (SHORTER THAN 1024 POINTS)'
        GO TO 999
  995   TYPE*,'DECODING ERROR'
        TYPE*,'SEE IF FILE VALUES ARE CORRECTLY ARRANGED'
        GO TO 999
  991   TYPE*,'SAVING FILE CAN NOT BE OPENED'
        GO TO 999
  989   TYPE*,'IT IS NOT POSSIBLE TO ENCODE YOUR NEW DATA'
  999   CLOSE(UNIT=2)
C
  100   FORMAT(I1)
  200   FORMAT(6A1)
  300   FORMAT(64A1)
  400   FORMAT(9F7.0)
  500   FORMAT(A1)
  600   FORMAT(F7.1,8F7.0)
  700   FORMAT(' ',64A1)
```

```
      END
C
C
C
C
C
C
C
C
C
      SUBROUTINE SPC
C
      COMMON YAXE1
      DIMENSION YAXE1(1024),CF(103),DIODF(1024)
      INTEGER CHNR,CL,CH,WAVEL(103),W1,W2,LAMB1,LAMB2,I,J,K,NSPNR,A,B,
     &NCH,IWL1,SCALE
      REAL WPCH,IWL,TNMAX
C
    3 TYPE*,
      TYPE*,'WHAT TYPE OF MONOCHROMATOR HAS BEEN USED?'
      TYPE*,'1) SMALL MONOCHROMATOR'
      TYPE*,'2) MEDIUM MONOCHROMATOR'
      TYPE*,'3) 2M EBERT SPECTROGRAPH'
      TYPE*,'ANSWER(1/2/3)'
      ACCEPT 100,MNR
      IF(MNR.GT.3.OR.MNR.LT.1) GO TO 3
C
   30 TYPE*,
      TYPE*,'DO THE 1024 CHANNELS CONTAIN ONE OR TWO SPECTRA?'
      TYPE*,'(ANSWER 1/2)'
      ACCEPT 100,NSPNR
      IF(NSPNR.EQ.1.OR.NSPNR.EQ.2) GO TO 2
      GO TO 30
C
    2 GO TO (1,40,40) MNR
      GO TO 3
C
C     LILLA MONOKROMATORN
    1 OPEN(UNIT=3,NAME='MONOC1',ERR=994,TYPE='OLD')
      GO TO 50
C
C     MELLANMONOKROMATORN OCH 2M EBERT SPEKTROGRAF
   40 TYPE*,
      TYPE*,'FROM WHAT REGION IS YOUR SPECTRUM?'
      TYPE*,'1) INFRARED        (768NM)'
      TYPE*,'2) VISIBLE         (525NM)'
      TYPE*,'3) ULTRAVIOLET     (348NM)'
      TYPE*,'ANSWER (1/2/3)'
      ACCEPT 100,NREG
      IF(NREG.GT.3.OR.NREG.LT.1) GO TO 40
C
      GO TO (61,62,63) NREG
      GO TO 40
   61 OPEN(UNIT=3,NAME='IRKOMP',ERR=994,TYPE='OLD')
      GO TO 50
   62 OPEN(UNIT=3,NAME='VIKOMP',ERR=994,TYPE='OLD')
      GO TO 50
   63 OPEN(UNIT=3,NAME='UVKOMP',ERR=994,TYPE='OLD')
C
   50 READ(3,700) DIODF
      CLOSE(UNIT=3)
C
      DO 51 I=1,512
      K=NSPNR*(I-1)+1
      YAXE1(I)=YAXE1(I)*DIODF(K)
   51 CONTINUE
C
      DO 52 I=513,1024
      K=NSPNR*(I-1-(NSPNR-1)*512)+1
      YAXE1(I)=YAXE1(I)*DIODF(K)
```

```
C     OVERFLOW TEST
   32 TNMAX=1.0
      YAXE1(1)=10.
      YAXE1(2)=10.
      YAXE1(3)=10.
      YAXE1(4)=10.
      YAXE1(1021)=10.
      YAXE1(1022)=10.
      YAXE1(1023)=10.
      YAXE1(1024)=10.
      IF(NSPNR.EQ.1) GO TO 33
      YAXE1(511)=10.
      YAXE1(512)=10.
      YAXE1(513)=10.
      YAXE1(514)=10.
C
   33 DO 24 L=1,1024
      TNMAX=AMAX1(TNMAX,YAXE1(L))
   24 CONTINUE
C
      IF(TNMAX.GT.999999.) GO TO 25
      GO TO 26
   25 TYPE*,
      TYPE*,'WARNING: VALUES EXCEED 1,000,000 WHICH CAN NOT BE '
      TYPE*,'ACCEPTED BY TRACOR NORTHERN ANALYZER'
      TYPE*,'AUTOMATIC SCALING WILL BE PERFORMED'
      SCALE=TNMAX/950000.
C
      DO 27 I=1,1024
      YAXE1(I)=YAXE1(I)/SCALE
   27 CONTINUE
C
      GO TO 26
  994 TYPE*,
      TYPE*,'READING ERROR'
      STOP
C
  100 FORMAT(I1)
  200 FORMAT(1X,'CHANNEL NO   ',I4,'   CORRESPONDS TO')
  300 FORMAT(A1)
  400 FORMAT(I4)
  500 FORMAT(1X,'VALUES FOR CL,CH,LAMB1,LAMB2 ARE',//,1X,4I7)
  600 FORMAT(I4)
  700 FORMAT(F10.4)
  800 FORMAT(1X,'WAVELENGTH   ',I4)
C
   26 RETURN
      END
C
C
C
C
C
C
C
C
C
C
      SUBROUTINE SPD
C
      COMMON YAXE1
      DIMENSION YAXE1(1024)
      INTEGER CHNL1,CHNL2,CHNL3,CHNL4,IA,NCH
      REAL FACT,TNMAX,SCALE
C
   10 IA=0
      TYPE*,
      TYPE*,'WHICH CHANNELS DO YOU WANT TO DIVIDE?'
      TYPE*,'THE CHANNELS SHOULD BE GIVEN IN TWO GROUPS,'
      TYPE*,'WERE THE CHANNELS IN THE SECOND GROUP WILL BE'
```

```
      TYPE*,'FIRST GROUP, AND CHNL2 REFERS TO THE HIGHEST ONE.'
      TYPE*,'SIMILAR ORDER FOR CHNL3 AND CHNL4 IN THE 2:ND GROUP.'
      TYPE*,
      TYPE*,'BOTH GROUPS MUST CONTAIN THE SAME NUMBER OF CHANNELS'
      TYPE*,
      TYPE*,'THE RESULT CAN BE FOUND IN CHANNELS CHNL3-CHNL4'
      TYPE*,'OBSERVE THAT OTHER VALUES THAN THOSE IN'
      TYPE*,'CHNL3-CHNL4 MAY BE CHANGED DURING CALCULATIONS'
      TYPE*,
    4 TYPE*,'CHNL1='
      ACCEPT 100,CHNL1
      IF(IA.EQ.1) GO TO 8
    5 TYPE*,'CHNL2='
      ACCEPT 100,CHNL2
      IF(IA.EQ.1) GO TO 8
    6 TYPE*,'CHNL3='
      ACCEPT 100,CHNL3
      IF(IA.EQ.1)GO TO 8
    7 TYPE*,'CHNL4='
      ACCEPT 100,CHNL4
C
    8 IA=0
      TYPE*,
      WRITE(7,200) CHNL1,CHNL2,CHNL3,CHNL4
    1 TYPE*,
      TYPE*,'DO YOU WANT TO CHANGE ANYONE OF THESE?(Y/N)'
      ACCEPT 300,ANSWER
      IF(ANSWER.EQ.'Y') GO TO 2
      IF(ANSWER.EQ.'N') GO TO 3
      GO TO 1
C
    2 IA=1
      TYPE*,
      TYPE*,'WHICH CHANNEL NO DO YOU WANT TO CHANGE?(1/2/3/4)'
      ACCEPT 400,NCH
      GO TO (4,5,6,7) NCH
      GO TO 2
C
C     INDATA TEST
    3 IF(CHNL2-CHNL1.NE.CHNL4-CHNL3) GO TO 30
      IF(CHNL1.LT.1.OR.CHNL1.GT.1024) GO TO 30
      IF(CHNL2.LT.1.OR.CHNL2.GT.1024) GO TO 30
      IF(CHNL3.LT.1.OR.CHNL3.GT.1024) GO TO 30
      IF(CHNL4.LT.1.OR.CHNL4.GT.1024) GO TO 30
      GO TO 15
   30 TYPE*,
      TYPE*,'ERROR IN INPUT DATA, YOU MUST REPEAT THE INPUT PROCEDURE'
      TYPE*,
      GO TO 10
C
   15 TYPE*,
      TYPE*,'DO YOU WANT TO MULTIPLY THE VALUES BELONGING TO'
      TYPE*,'CHNL1-CHNL2 WITH A FACTOR?(Y/N)'
      ACCEPT 300,ANSWER
      IF(ANSWER.EQ.'Y') GO TO 16
      IF(ANSWER.EQ.'N') GO TO 17
      GO TO 15
   16 TYPE*,
      TYPE*,'GIVE THE FACTOR PLEASE (F-FORMAT F12.5)'
      ACCEPT 500,FACT
      TYPE*,
      WRITE(7,600) FACT
      TYPE*,
      TYPE*,'DO YOU WANT TO CHANGE IT?(Y/N)'
      ACCEPT 300,ANSWER
      IF(ANSWER.EQ.'N') GO TO 18
      GO TO 16
C
   18 DO 19 I=CHNL1,CHNL2
      YAXE1(I)=YAXE1(I)*FACT
```

```
   17 K=CHNL1
C
      DO 20 I=CHNL3,CHNL4
      IF(YAXE1(I).EQ.0.) YAXE1(I)=1.0
      IF(YAXE1(K).EQ.0.) YAXE1(K)=1.0
      YAXE1(I)=YAXE1(I)/YAXE1(K)
      K=K+1
   20 CONTINUE
C
C     OVERFLOW-TEST
      TNMAX=1.0
C
      DO 21 I=1,1024
      TNMAX=AMAX1(TNMAX,YAXE1(I))
   21 CONTINUE
C
      IF(TNMAX.GT.999999.) GO TO 22
      GO TO 24
   22 TYPE*,
      TYPE*,'WARNING: VALUES EXCEED 1,000,000 WHICH CAN NOT BE ACCEPTED'
      TYPE*,'BY TRACOR NORTHERN ANALYZER'
      TYPE*,'AUTOMATIC SCALING WILL BE PERFORMED'
      SCALE=TNMAX/950000.
C
   23 DO 24 I=1,1024
      YAXE1(I)=YAXE1(I)/SCALE
   24 CONTINUE
C
C
  100 FORMAT(I4)
  200 FORMAT(1X,'GIVEN VALUES FOR CHNL1-CHNL4 ARE',//1X,4I6)
  300 FORMAT(A1)
  400 FORMAT(I1)
  500 FORMAT(F12.5)
  600 FORMAT(1X,'GIVEN MULTIPLICATION FACTOR IS',//1X,F12.5)
C
      RETURN
      END
```

```
      PROGRAM [illegible]1
      DIMENSION XAX[illegible](1[illegible]),YAX[illegible]1(1[illegible]4),YAX[illegible](1[illegible]24)
      [illegible]Y[illegible] LIN[illegible]([illegible])
C
C
      OPEN(UNIT=[illegible],NA[illegible]E='[illegible].TN[illegible]',[illegible]=1[illegible],TYPE='OLD')
      READ([illegible],1[illegible]) LIN[illegible]
      READ([illegible],1[illegible]) LIN[illegible]
      READ([illegible],1[illegible]) LIN[illegible]
      READ([illegible],1[illegible]) LIN[illegible]
C
      DO 1 K=1,100
      N2=[illegible]*[illegible]
      N1=N2-[illegible]
      READ([illegible],1[illegible],[illegible]=1[illegible]) LIN[illegible]
      DECODE([illegible],[illegible],LIN[illegible],ERR=1[illegible]) XAXE(K),(YAXE1(I),I=N1,N2)
    1 CONTINUE
C
      CLOSE(UNIT=[illegible])
C
      DO [illegible] I=1,1[illegible]
      IF(YAX[illegible]1(I).[illegible].1.) YAX[illegible]1(I)=1[illegible].
    [illegible] CONTINUE
C
      OPEN(UNIT=[illegible],[illegible]E='[illegible].TN[illegible]',[illegible]=1[illegible],TYPE='OLD')
      READ([illegible],1[illegible]) LIN[illegible]
      READ([illegible],1[illegible]) LIN[illegible]
      READ([illegible],1[illegible]) LIN[illegible]
      READ([illegible],1[illegible]) LIN[illegible]
C
      DO [illegible] K=1,[illegible]
      N2=[illegible]
      N1=N2-[illegible]
      READ([illegible],1[illegible],[illegible]=1[illegible]) LIN[illegible]
      DECODE([illegible],[illegible],LIN[illegible],[illegible]=[illegible]) XAX[illegible](K),(YAXE2(I),I=N1,N2)
    [illegible] CONTINUE
C
      CLOSE(UNIT=[illegible])
      OPEN(UNIT=[illegible],[illegible]E='[illegible]',[illegible]=1[illegible],TYPE='OLD')
C
      DO [illegible] I=1,1[illegible]
      YA[illegible](I)=YA[illegible](I)/YA[illegible]1(I)
      WRITE([illegible],[illegible]) YA[illegible](I)
    [illegible] CONTINUE
C
      CLOSE(UNIT=[illegible])
C
 1000 TYPE*,'[illegible]'
      [illegible]
 [illegible] TYPE*,'[illegible]'
C
  1[illegible] FORMAT([illegible])
  [illegible] FORMAT([illegible])
  [illegible] FORMAT([illegible])
C
      END
```