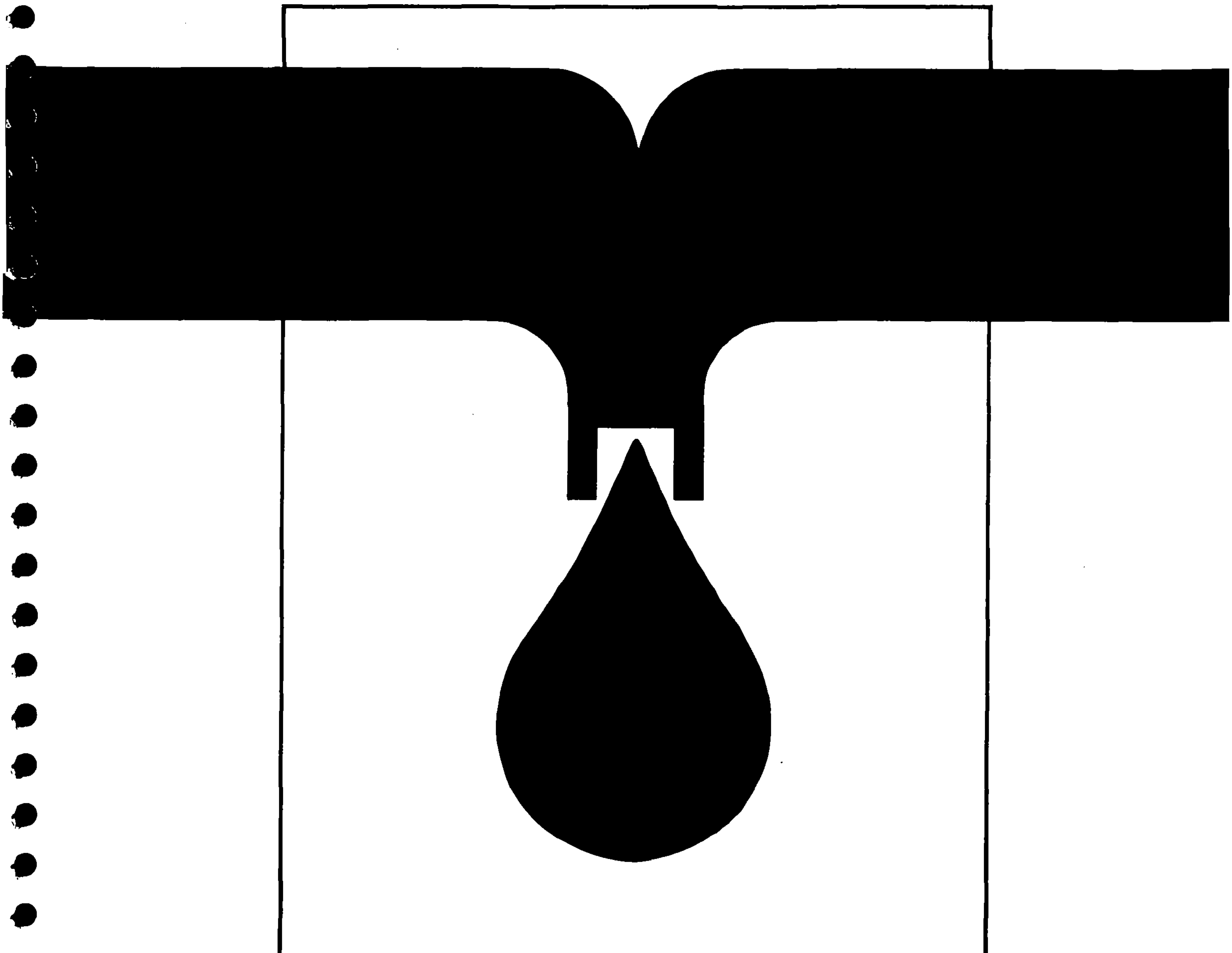
TRAINING MODULES FOR WATERWORKS PERSONNEL



Special Skills

3.11

Simple surveying and drawing work

Foreword

Even the greatest optimists are no longer sure that the goals of the UN "International Drinking Water Supply and Sanitation Decade", set in 1977 in Mar del Plata, can be achieved by 1990. High population growth in the Third World combined with stagnating financial and personnel resources have led to modifications to the strategies in cooperation with developing countries. A reorientation process has commenced which can be characterized by the following catchwords:

- use of appropriate, simple and – if possible – low-cost technologies,
- lowering of excessively high water-supply and disposal standards,
- priority to optimal operation and maintenance, rather than new investments,
- emphasis on institution-building and human resources development.

Our training modules are an effort to translate the last two strategies into practice. Experience has shown that a standardized training system for waterworks personnel in developing countries does not meet our partners' varying individual needs. But to prepare specific documents for each new project or compile them anew from existing materials on hand cannot be justified from the economic viewpoint. We have therefore opted for a flexible system of training modules which can be combined to suit the situation and needs of the target group in each case, and thus put existing personnel in a position to optimally maintain and operate the plant.

The modules will primarily be used as guidelines and basic training aids by GTZ staff and GTZ consultants in institution-building and operation and maintenance projects. In the medium term, however, they could be used by local instructors, trainers, plant managers and operating personnel in their daily work, as check lists and working instructions.

45 modules are presently available, each covering subject-specific knowledge and skills required in individual areas of waterworks operations, preventive maintenance and repair. Different combinations of modules will be required for classroom work, exercises, and practical application, to suit in each case the type of project, size of plant and the previous qualifications and practical experience of potential users.

Practical day-to-day use will of course generate hints on how to supplement or modify the texts. In other words: this edition is by no means a finalized version. We hope to receive your critical comments on the modules so that they can be optimized over the course of time.

Our grateful thanks are due to

Prof. Dr.-Ing. H. P. Haug
and
Ing.-Grad. H. Hack

for their committed coordination work and also to the following co-authors for preparing the modules:

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It is my sincere wish that these training modules will be put to successful use and will thus support world-wide efforts in improving water supply and raising living standards.

Dr. Ing. Klaus Erbel
Head of Division
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Eschborn, May 1987

Title:

Simple surveying and drawing work

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Simple surveying and drawing work

1. Surveying work

1.1. Practical hints on the measurement of horizontal lengths

1. Measuring rods, surveyor's tapes and tape measures are length-measuring devices of equal value; in the order listed here, however, they represent decreasing degrees of accuracy. Good results can be achieved with all three, provided that the measurements are carried out carefully and precautions aimed at avoiding errors are observed.

2. If measuring rods are employed, a pair of rods (not a single rod) must always be used; they must be checked on a comparator before and after every major surveying operation. The measuring results must then be corrected. The influence of temperature changes is so slight in the case of measuring rods that it can be ignored.

3. Tape measures and surveyor's tapes made of steel must be checked every so often. It is a good idea to draw up a table for each tape, from which the corrections to be made at any specific ambient temperature can be read off. These corrections can be immediately taken into account on the spot when individual lengths are being determined.

4. If a tape measure or surveyor's tape is used, the tape tension must be kept even. The spring balance in the handle of the tape is an excellent aid in achieving this.

5. The measuring devices must be cleaned after use; tape measures and steel surveyor's tapes must be greased in order to protect them against corrosion.

6. The distance to be measured must be made clearly visible with an adequate number of supplementary points by means of range poles so that the front man on the measuring device can align himself in the direction of measurement.

7. In inclined terrain the measuring device is either held horizontal (using a spirit level, not by eye) and the horizontal distance immediately determined using the horizontal step method, or placed on the ground and the measured slope distance reduced to the horizontal. If measuring rods are used, the reduction is

determined with the aid of a graduated arc, but if a tape measure or surveyor's tape is employed it is established with the aid of a clinometer.

8. Every measurement is to be backed up by suitable checks, possibly by double measurement.

1.2 Levelling

"Levelling" means measuring the differences in elevation (height) between two or more points. The accuracy of such measurements is determined by the purpose for which they are required and depends on the available measuring equipment. Elevation-measuring equipment is featured in Module 2.11.

1.2.1 Simple measurement of elevations using a staff

In steep terrain, the horizontal step method, using staff and metre rule, is often employed if cross-sections are to be surveyed and only a moderate degree of accuracy is required. A level rod held horizontally can also be used as a staff in this case.

Starting at post A, which is 773.5 m above sea level, the height of the final point B is as follows: $H_B = 773.5 - 1.5 - 1.7 - 1.4 = 768.9$ m above sea level.

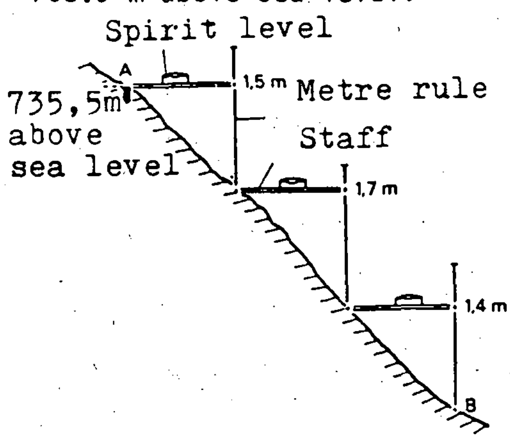


Fig. 2.1 Horizontal step measurement

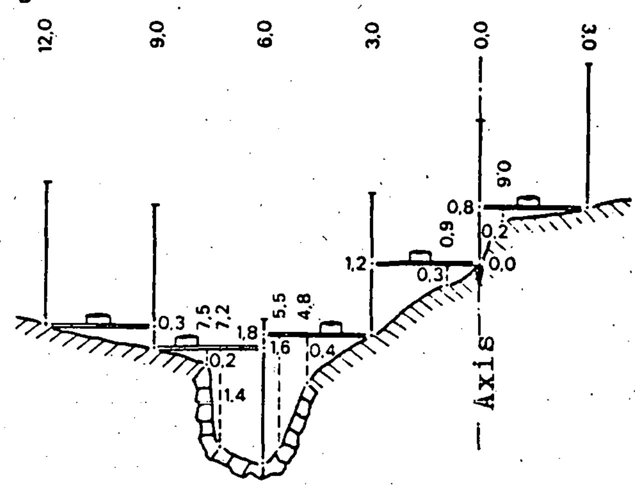
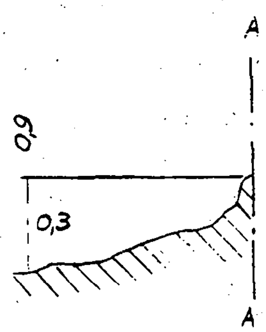


Fig. 2.2 Cross-section with staff and metre rule

Distances from the axis are shown offset by 90° with respect to the elevation figures.

Example:



The difference in elevation is 0.3 m at a distance of 0.9 m from axis A - A

1.2.2 Simple measurement of elevations using an angle prism

Elevations can be roughly measured using an angle prism tilted 90°. Looking into the square, the eye sees the image L', in the horizontal, of the freely hanging plumb bob L, so that the distance can be read off in the horizontal line of sight from a rod. As in the case of levelling, the angle prism is used for fore-sight and backsight with equal ranges.

The observer's eye level corresponds to the height of the instrument as shown in Fig. 3.1

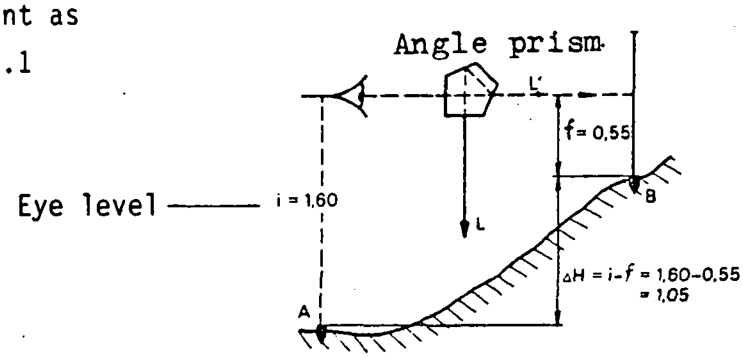


Fig. 3.1

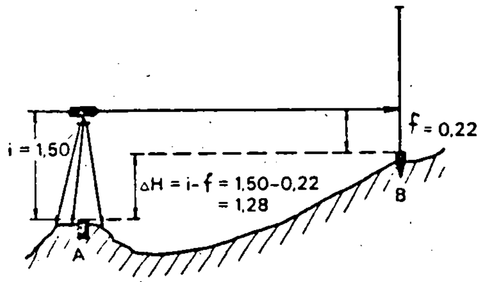
1.2.3 Measurement of elevations using a level

If differences in elevation over lengthy distances are to be measured accurately, an appropriate measuring instrument must be used. The surveyor's level is particularly suitable for this purpose. Any of the following three instrument positions can be used for determining the difference in elevation between two points:
Instrument positioned above one of the two points, between the points or behind both of the points.

Instrument positioned above one of the two points.

The instrument is positioned, for example, above the point of known height A and the height of the instrument measured. The term "height of the instrument" refers to the distance between the ground point A and the centre of the telescope. A level rod (rod with graduated centimetre scale) or a metre rule is then placed on the new point B and the foresight f read off.

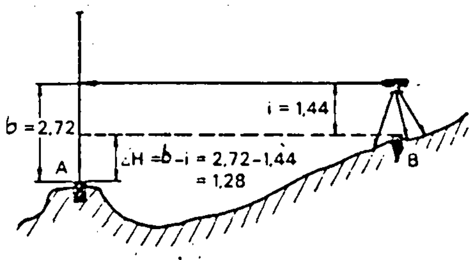
The difference in elevation between A and B is the height of the instrument minus the foresight.



$$H_B = H_A + i - f$$

Fig. 4.1

If the instrument is positioned above the new point B and the rod above the point A with known height H_A, the backsight b is read off from the rod above A and the difference in elevation between A and B is obtained in the form of the difference between the backsight b and the height of the instrument i, H = (b - i).



$$H_B = H_A + b - i$$

Fig. 4.2

This yields the following rule:

The backsight, i.e. the reading taken looking towards the point of known height, is always positive.

The foresight, i.e. the reading taken looking forwards to the new point, is always negative.

Instrument positioned between the point of known height A and the new point B.

The instrument should be positioned roughly equidistant between the two points. It is unimportant, however, whether the instrument is in the straight line between A and B or outside it.

The rod is set up vertically above A and the backsight b read off. The rod is then moved to point B - without the position of the level being changed - and the foresight f is then read off.

The difference in elevation between A and B = + b - f

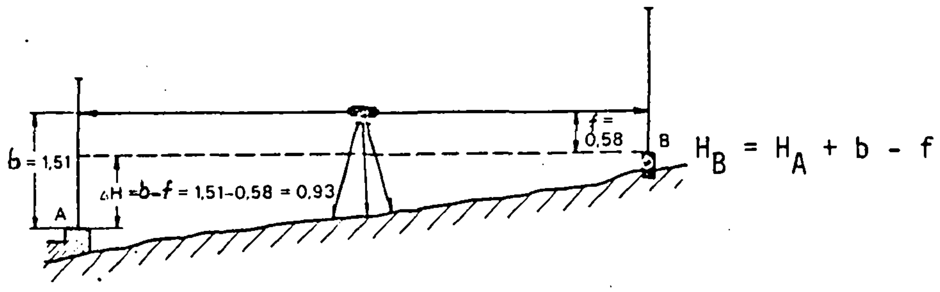


Fig. 5.1

Instrument positioned behind the two points.
The reading is taken above point A (backsight) and at the new point B (foresight). The difference in elevation between A and B is once again: + b - f.

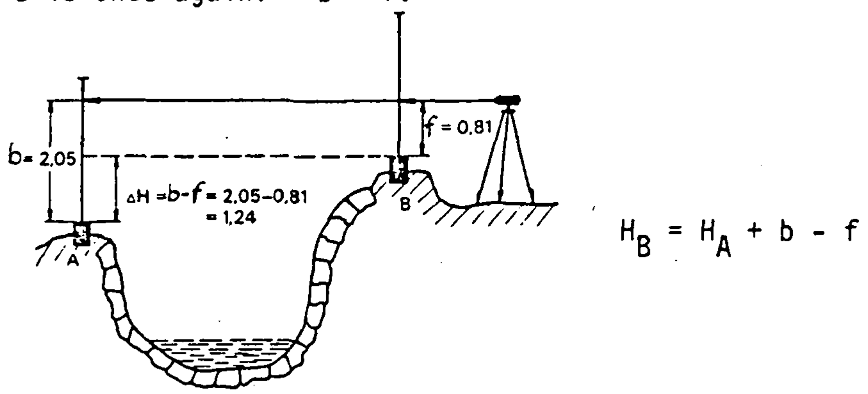


Fig. 5.2

1.2.4 Running a line of levels

As in the case of horizontal step measurement with a staff, which has to be used several times if the distance between two measuring points is greater than the length of the staff or if the difference in elevation is greater than the metre rule is long, a "step" method must also be employed when running a line of levels; the range is generally up to 50 - 60 m if the terrain so permits, and may be somewhat shorter if the terrain is extremely steep.

The rod is positioned on the starting point A = 1. The instrument location i_1 is selected such that the horizontal backsight does not fall beyond the upper end of the rod above 1 and the foresight still falls on the rod above 2, which is positioned at roughly the same range distance on point 2 (levelling from the centre).

The readings for b (backsight) and f (foresight) are then taken at i_1. The level is then moved to i_2. The rod remains at the turning point 2 and is carefully turned so that its graduated scale is facing the new instrument position i_2. The same reading-off process as was performed at i_1 is then carried out, with the backsight b_2 to point 2 being determined and, once the rod has been moved to point 3, foresight f_2 etc. This procedure is continued until the last foresight f_3 has been read off at point B = 4. The readings b and f are entered in a field book in tabular form.

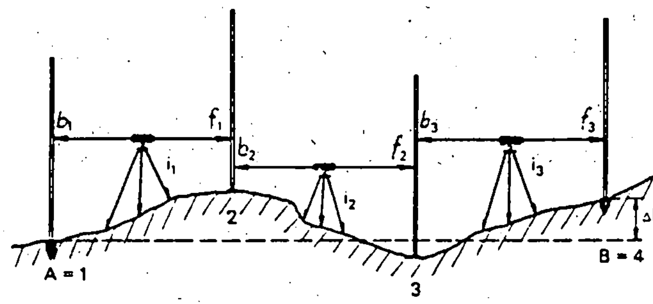


Fig. 6.1 Running a line of levels

Point no.	Backsight b	Foresight f	Remarks
A = 1	+ 2.50		b_1
2		- 1.80	f_1
2	+ 0.90		b_2
3		- 1.90	f_2
3	+ 3.10		b_3
B = 4		- 0.90	f_3
	+ 6.50	- 4.60	Total
	- 4.60	←	
H	+ 1.90	= Difference in elevation A-B	

If only the difference in elevation H between points A and B is required, it is sufficient to subtract the total of the foresights (-4.60) from the total of the backsights (+ 6.50):

H = 6.50 - 4.60 = 1.90.

Rule: Here again, the backsight reading b is always positive and the foresight reading f is always negative!

If the elevations of the rod turning points 2 and 3 (Fig. 6.1) are also required, the table and calculations as shown in example 2 should be used. The individual elevations are calculated in succession as follows:
b_1 (backsight) is added to the height above sea level of point A = 1, yielding the instrument horizon 1. f_1 is then subtracted from this, thereby yielding the height above sea level of point 2. b_2 is added to the height above sea level of point 2 and the instrument horizon 2 obtained. Subtraction of f_2 yields the height above sea level of point 3. To this figure is added b_3, wich yields the instrument horizon 3. Subtraction of f_3 then yields the height above sea level of point B = 4.

Point no.		Remarks
A = 1	650.00	Bench mark 20
b_1	+ 2.50	
$\otimes$	652.50	
f_1	- 1.80	
2	650.70	Curbstone
b_2	+ 0.90	
$\otimes$	651.60	
f_2	- 1.90	
3	649.70	Gully
b_3	+ 3.10	
$\otimes$	652.80	
f_3	- 0.90	
B = 4	651.90	Bench mark 21
A = 1	650.00	
H	+ 1.90	

$\otimes$= Instrument horizon

The operation of running a line of levels must be checked for correctness.

This can be done by finishing on a point of known elevation or by tracing the process back to the starting point.

The elevation calculated in the levelling process must then tally with the starting elevation or with the known elevation of a measuring point.
Only the turning points are retained in the reverse measurement process.

Continuous monitoring is possible through the use of two-sided level rods.

The graduated rod scales, to be found on the front and back or next to each other on one side, are staggered with respect to each other by a non-round amount, e.g. 3.335 m. In this way the levelling is carried out twice over, which means that the rod readings and the calculation are thoroughly double-checked and accuracy thereby increased. It is impossible, however, to keep a check on any change in the rod position during the period when the level is being moved.
If two rods are used, the secure footing of the instrument can be checked during measurement by taking readings in the following order: scale I backwards, scale I forwards, scale II forwards, scale II backwards.

Another method of double-checking during levelling is the use of double turning points.
Here again, levelling is carried out twice simultaneously; the readings at the turning points must be continuously checked. It is not possible to check the readings at the starting and finishing points, where the same rod is used for each levelling operation.

1.2.5 Throwing heights and levels from a known point

If several extra foresights are measured from an instrument position with horizon $\otimes$, e. g. for checking excavation in a building pit (Fig. 9.1), only one backsight will be entered in the table, namely the reading on the rod at the starting point A with the known elevation H_A.

All further readings on the rod at the extra foresight points are treated like foresights and entered in a second column. The individual elevations are then obtained in a third column by subtracting in each case the measured extra foresight e from the instrument horizon $\otimes$ = elevation H_A + backsight b = 594.20.

Point no.		Extra foresight -e	Elevation	Remarks
A	592.00			Bench mark 23
b_1	+ 2.20			
⊗	594.20			
f_1		- 1.80	592.40	Erratic block
f_2		- 1.90	592.30	Stone
f_3		- 2.50	591.70	Rock peak
f_4		- 2.30	591.90	Post
f_5		- 2.70	591.50	Channel

f_A	- 2.21			Check
A	591.99			

In order to check whether the level has remained in the same position during the measurement of the extra foresights, the rod at the starting point A is read again at the end of the process - this time as a foresight - and the elevation H_A obtained following subtraction of f.

Bench mark, 592 m above sea level

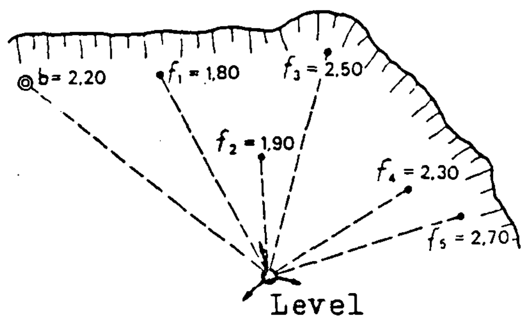


Fig. 9.1 Throwing heights and levels from a known point

2. Representation of simple bodies

2.1 Representation of 3 views using the projection lines

The front and side views which go with the plan views shown are to be drawn with the aid of the projection lines.

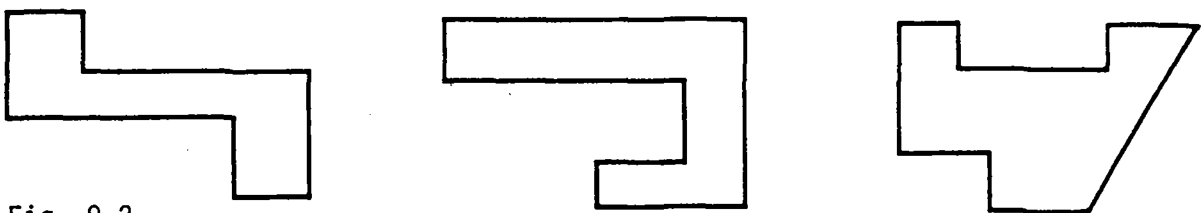


Fig. 9.2

Fig. 10.1 shows a representation in 3 views using the projection lines.

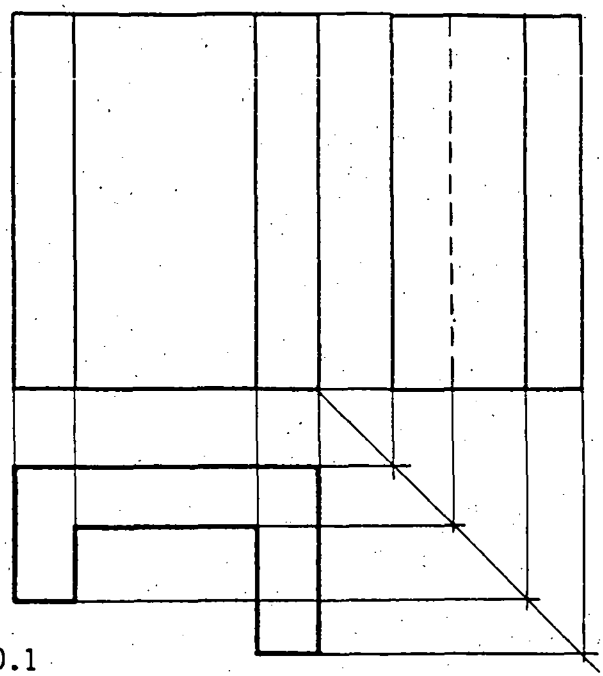


Fig. 10.1

Exercises: Reading drawings

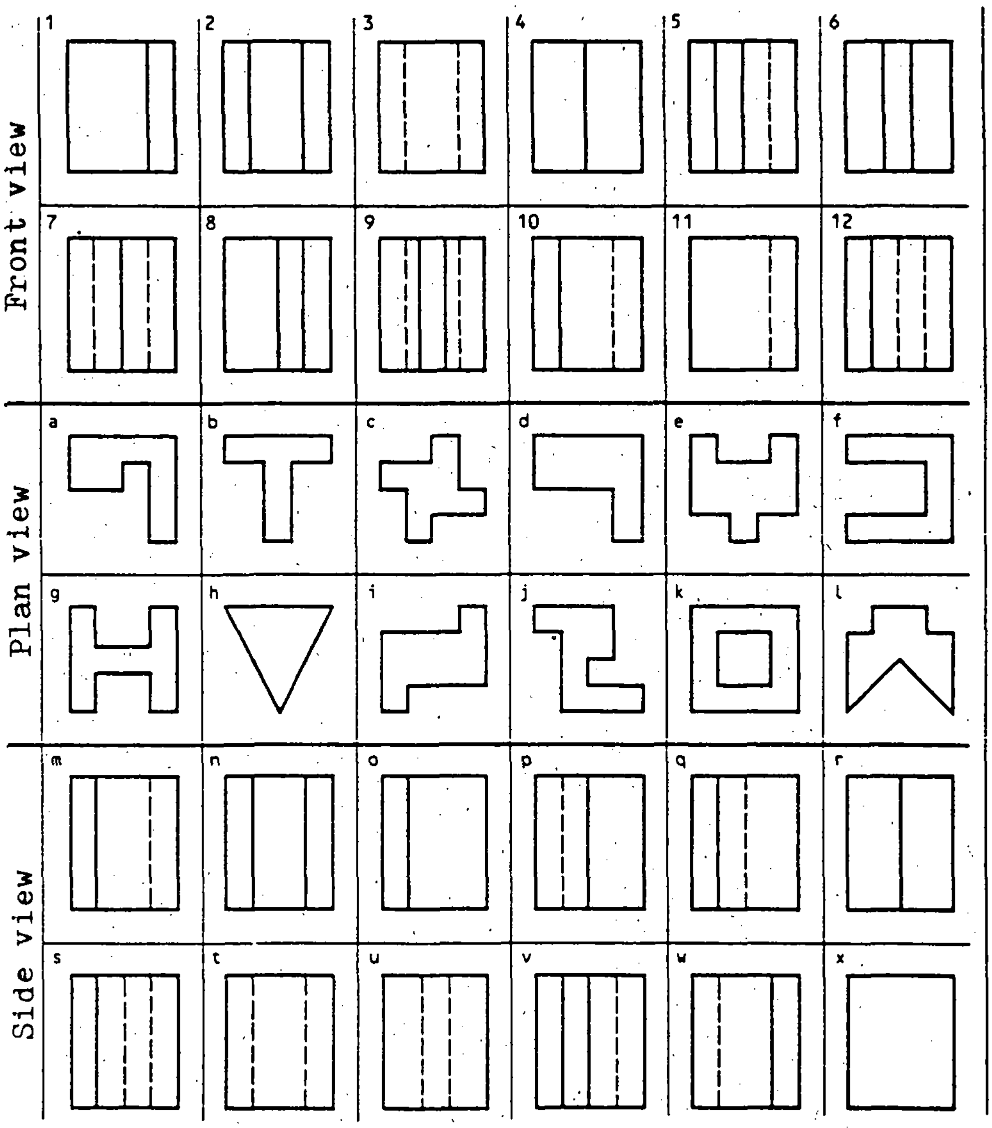


Fig. 10.2

The appropriate plan views (a...l) and side views (m...x) are to be matched to the front views (1...12). The letters are to be entered in the table.

Front view	1	2	3	4	5	6	7	8	9	10	11	12
Plan view												
Side view												

Table to accompany Fig. 10.2

Representation of simple components

Exercise 1

Draw and enter the dimensions for the pipe bend in front and side views.

Scale 1 : 1, DIN A4 horizontal

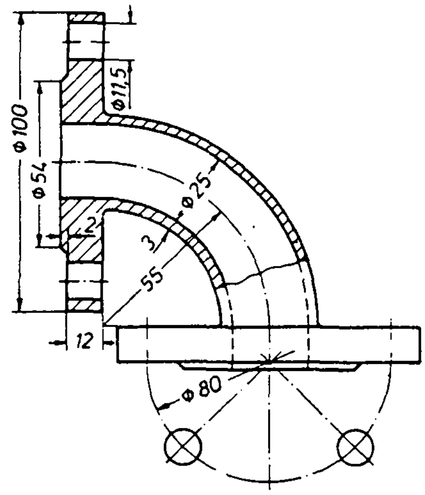


Fig. 11.1 (Ø ≡ dia)

Exercise 2

Draw the loose flange with 4 bolts. Front view in half section and plan view.

DIN A4 upright, scale 1 : 1

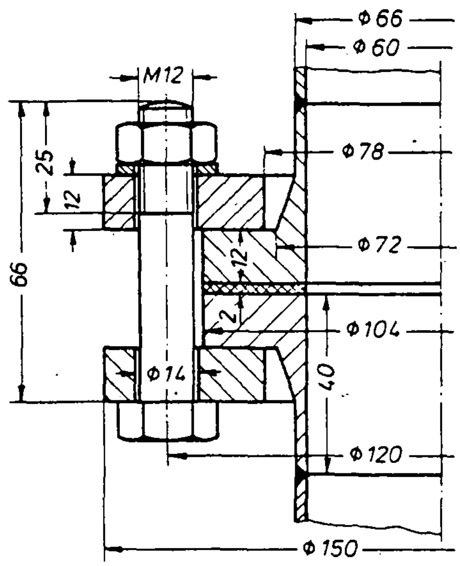
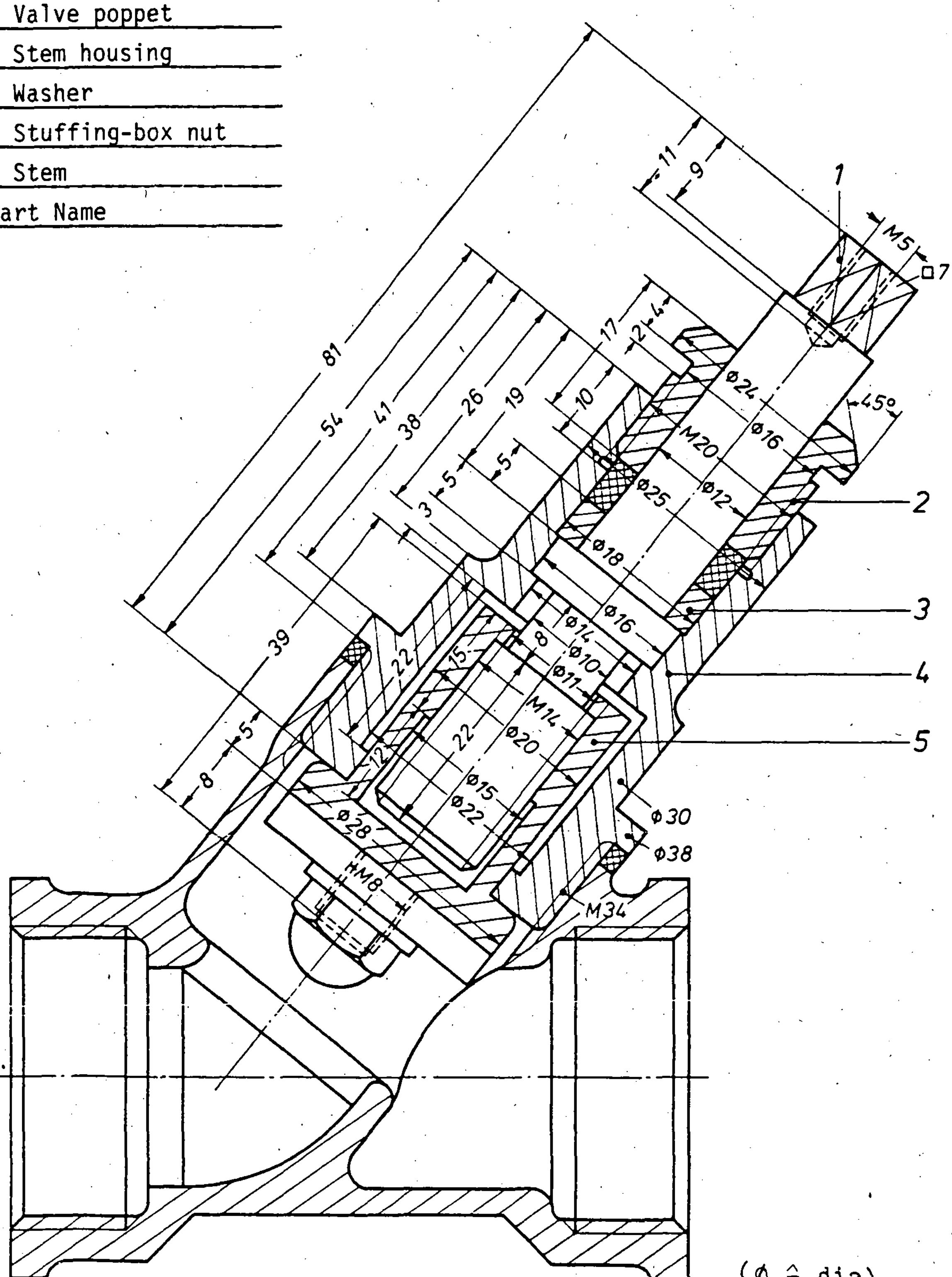


Fig. 11.2 (Ø ≡ dia)

Exercise 3

Sketch component 1 of the inclined valve and indicate the dimensions.

5	Valve poppet
4	Stem housing
3	Washer
2	Stuffing-box nut
1	Stem
Part	Name



(Ø ≙ dia)

3. Information signs

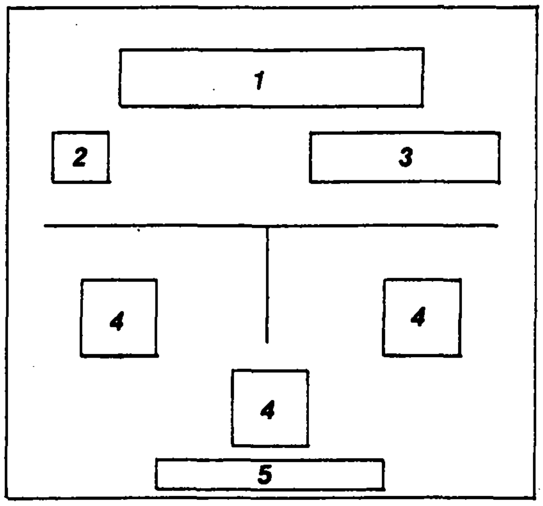
Information signs are required in order to identify pipeline components or water pipes and make it easy to relocate them.

There are three different areas of application:

Sign A for long-distance water pipelines
Sign B for local water distribution lines
Sign C for service headers

The information given on the signs is divided up over five sections.

Position of the sections on the sign



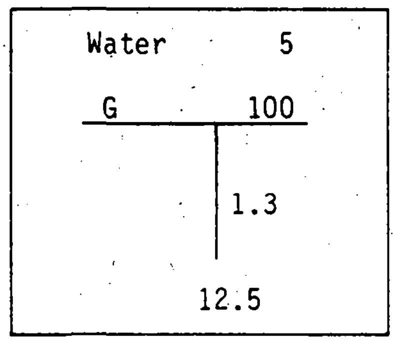
The information contained in the individual fields is as follows:

Section	Sign A	Sign B	Sign C
1	For data from the operator, e. g. number of item in the system plan, serial number or type of pipe fitting		-
2	Abbreviation for the pipeline component in question. The following abbreviations, for example, could be used: G = Gate valve DV = Drain valve VV = Vent valve B = Flap SC = Shutoff cock for service header SV = Shutoff valve for service header AV = Air valve		

Field	Sign A	Sign B	Sign C
3	Nominal diameter (DN) of pipeline		-
4	Distance from sign in metres to the left or right and/or to the front		
5	Information regarding service monitoring, e.g. name of operator, telephone number of responsible department	-	-

The sign shown, for example, is to be interpreted as follows:

Reference to gate valve No. 5 in a local water distribution line DN 100, located 12.5 m in front of the sign and 1.3 m to the right of it.
The signs have a blue background with white letters and figures.

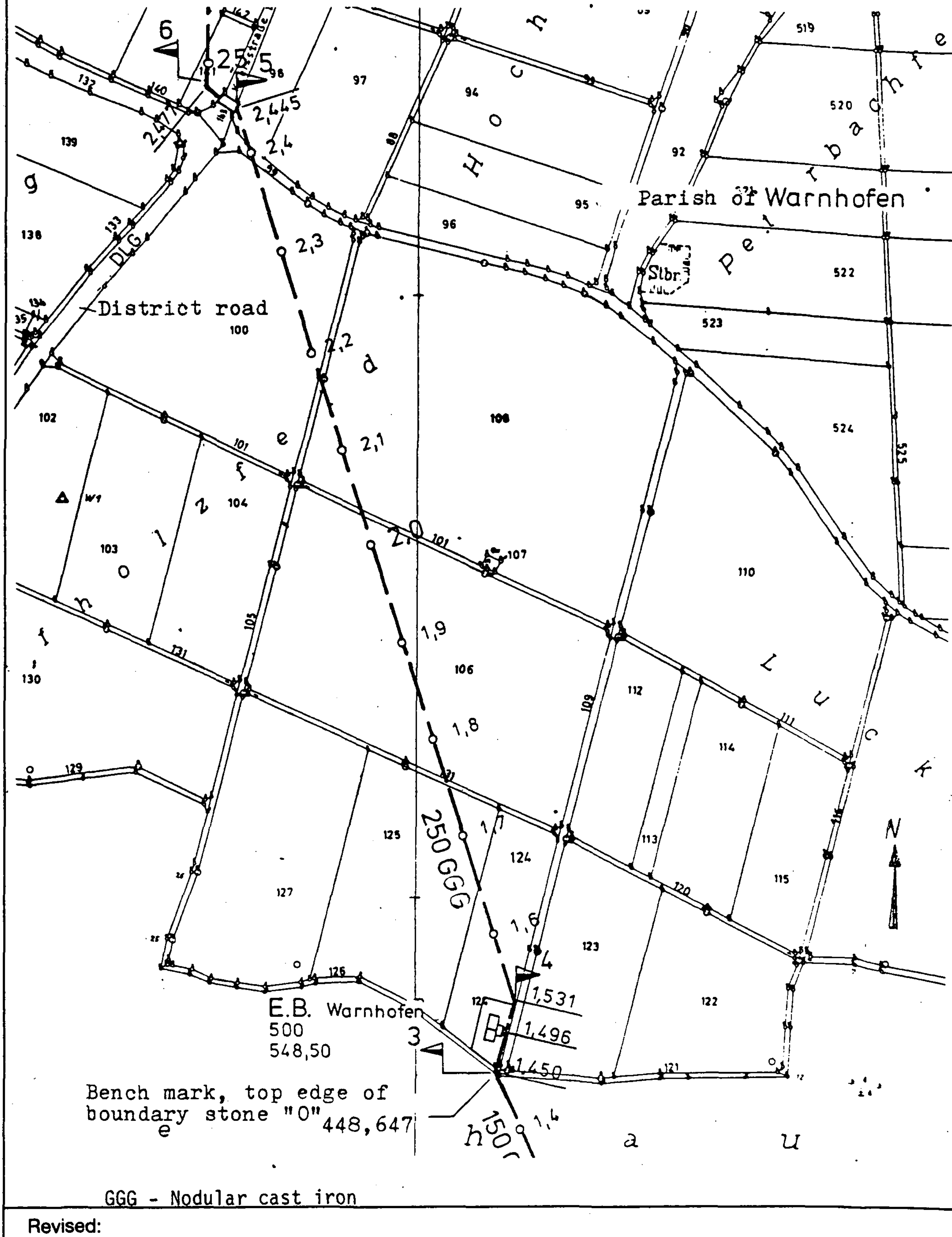


4. Location and plotting of angle points

The route taken by a pipeline is shown in the layout plan; this representation, however, is too inaccurate to permit relocation of the lines. Once pipelines have been laid, plans - which need not be to scale - are produced showing the angle points and branches. It is sufficient to use sketches which, when identifying the position of the angle points, take as their points of reference existing structures, boundary stones, manhole covers or other fixed points in the terrain. The angle points can be designated with consecutive numbers or with the relevant line length.
Example: AP 1 or AP St 211.2.

Section of a layout plan, scale 1 : 5000

Transmission main, km 1.4 - 2.5, with angle points 3 - 6



GGG - Nodular cast iron

Key (see Module 2.11, page 28 ff)

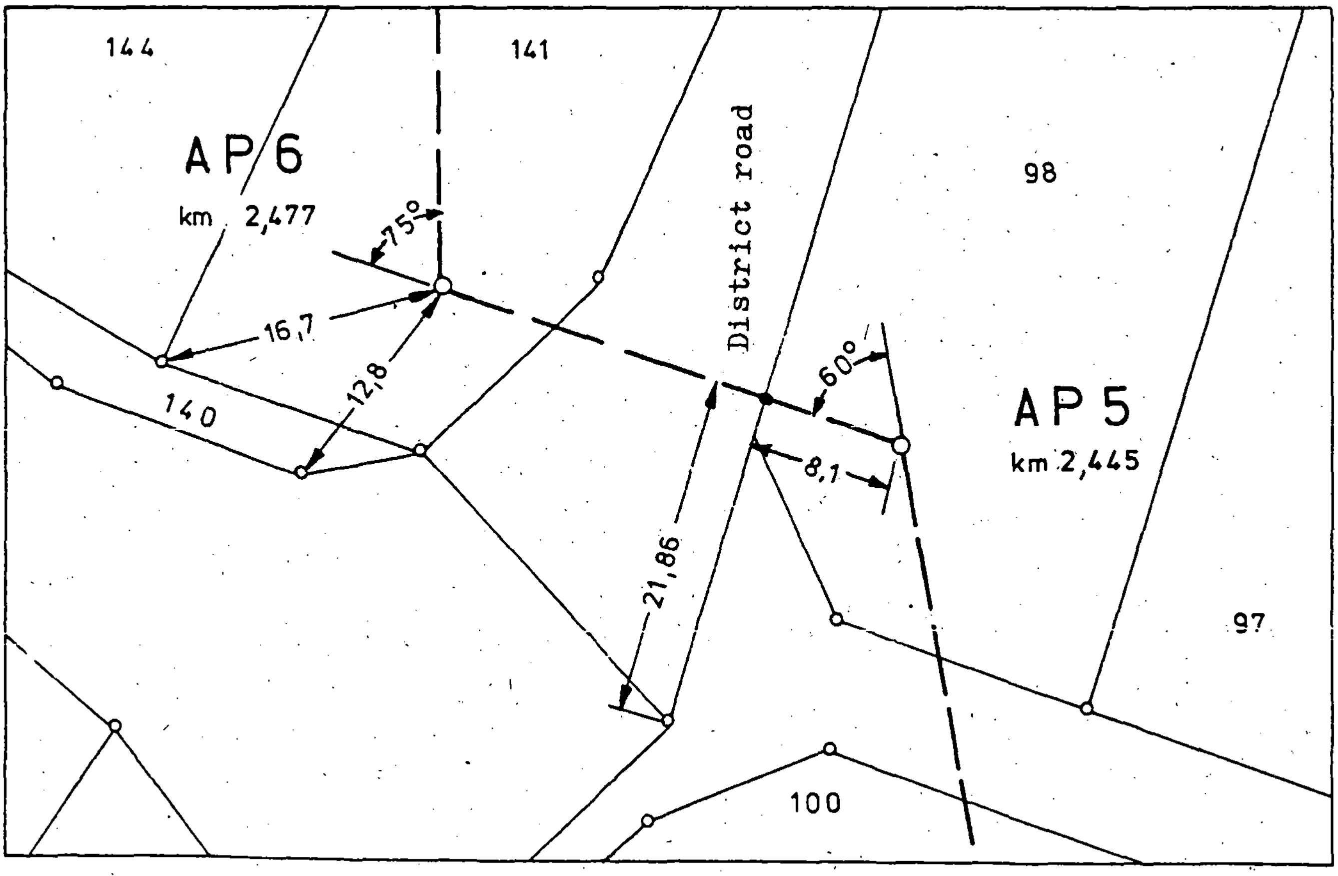
Planned pipeline

Road crossing, routing beneath road with protective tubing, without gate valve

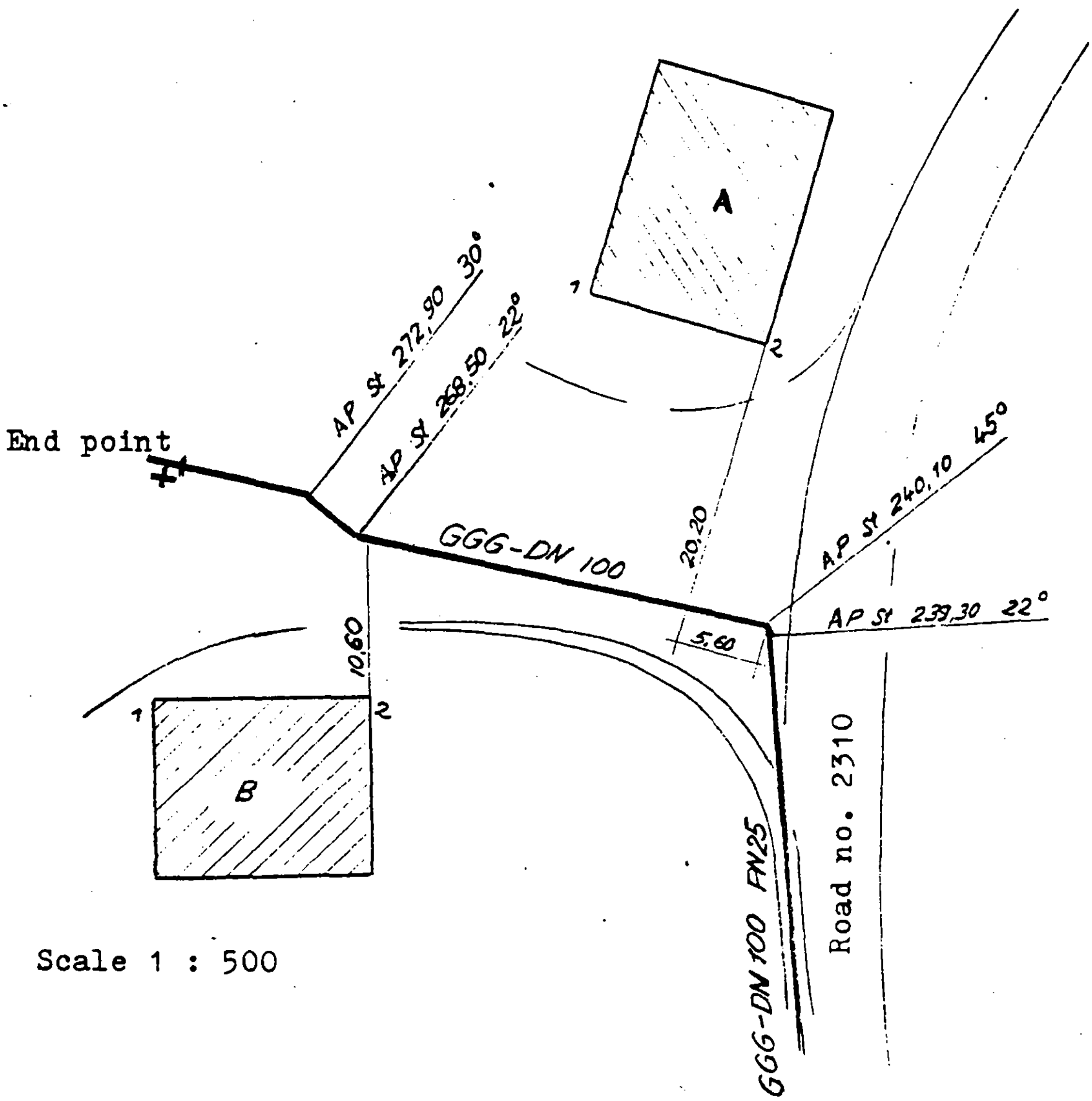
Angle point with number

Boundary stones

Sample plan for angle points AP 5 and AP 6.



Exercise 4:



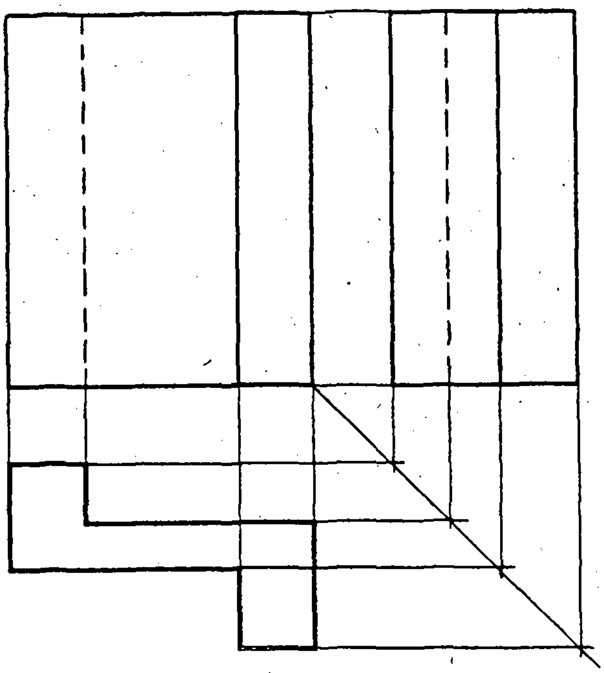
Scale 1 : 500

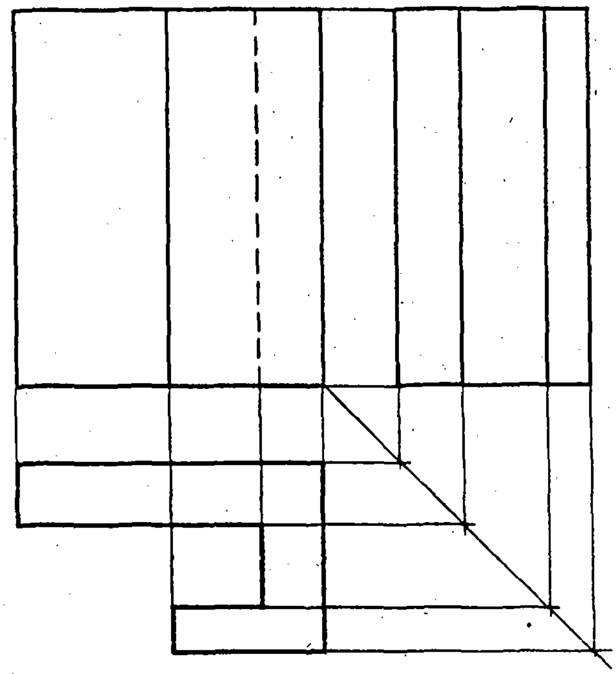
GGG = Nodular cast iron

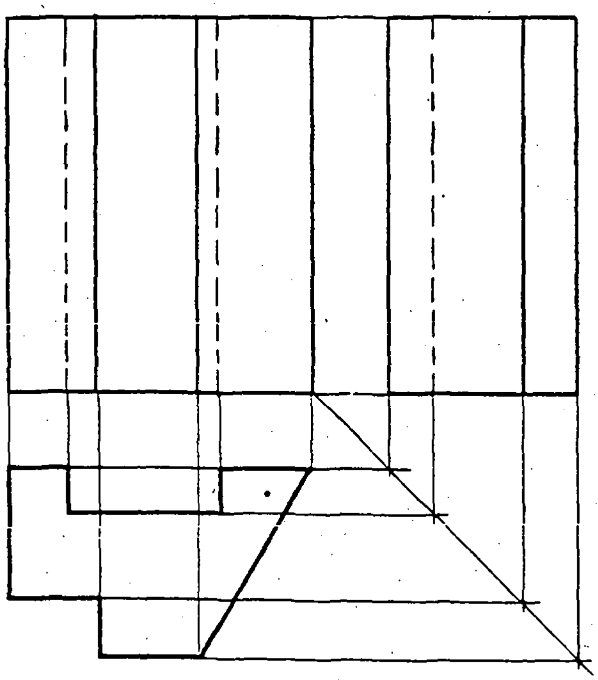
The positions of the end point and the four angle points of the pipeline are to be located in the pipeline plan. The reference points are the building corners A_1 and A_2 as well as B_1 and B_2.

5. Solutions to exercises

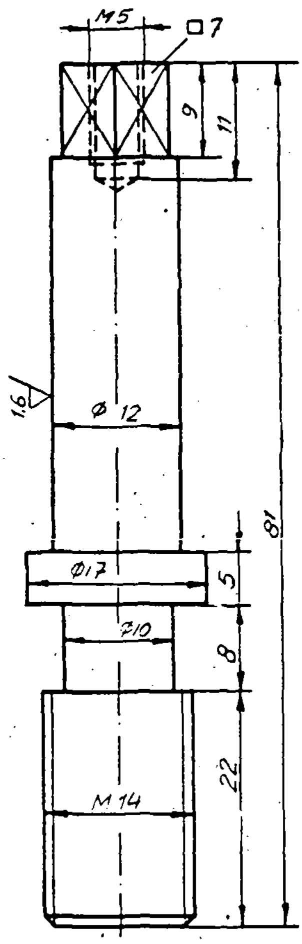
Solutions to 2.1



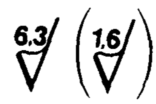




Solution to exercise 3



Stem

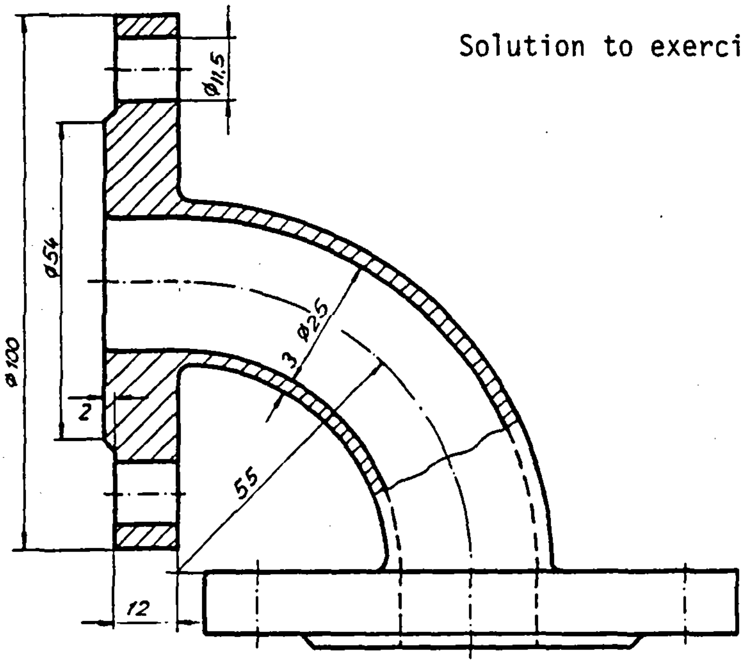


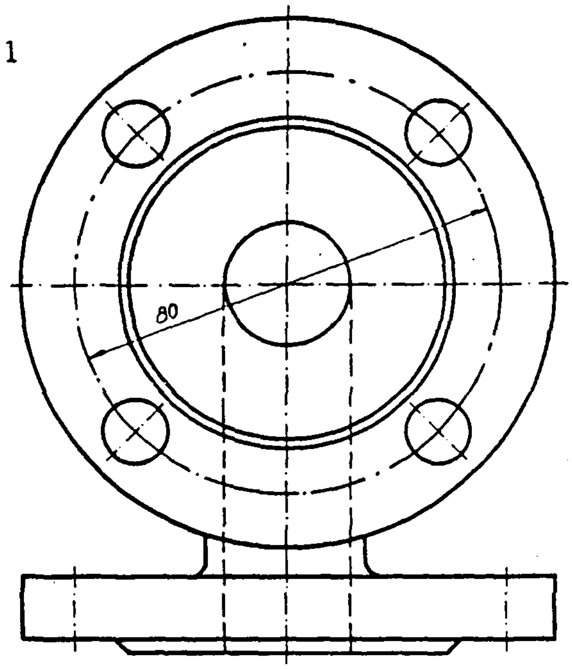
(Ø = dia)

Solution to Fig. 10.2

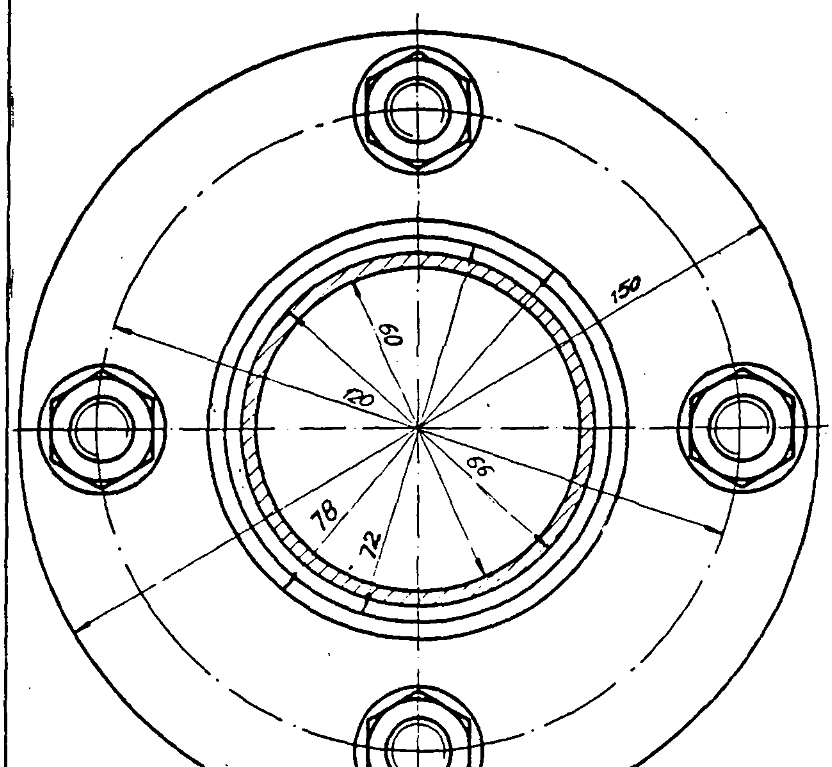
Front view	1	2	3	4	5	6	7	8	9	10	11	12
Plan view	d	g	k	h	c	b	l	a	e	i	f	j
Side view	r	u	t	x	v	o	q	p	w	m	n	s

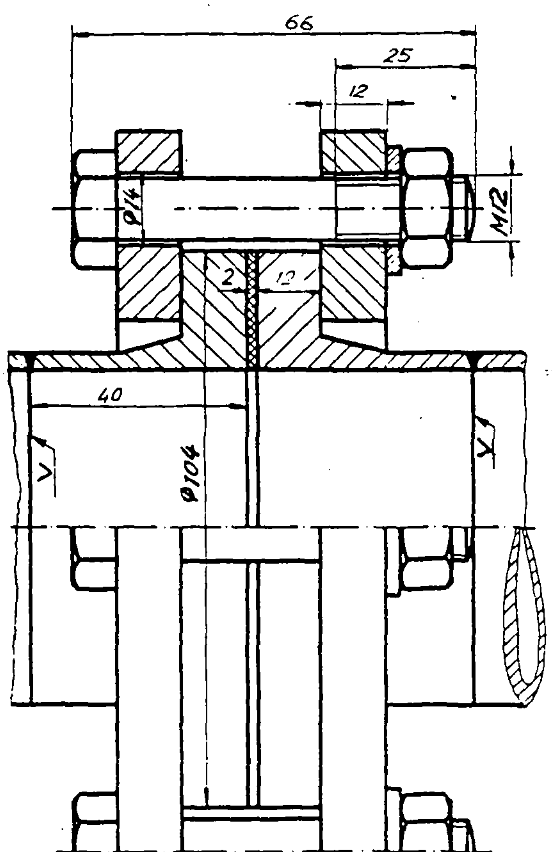
Solution to exercise 1



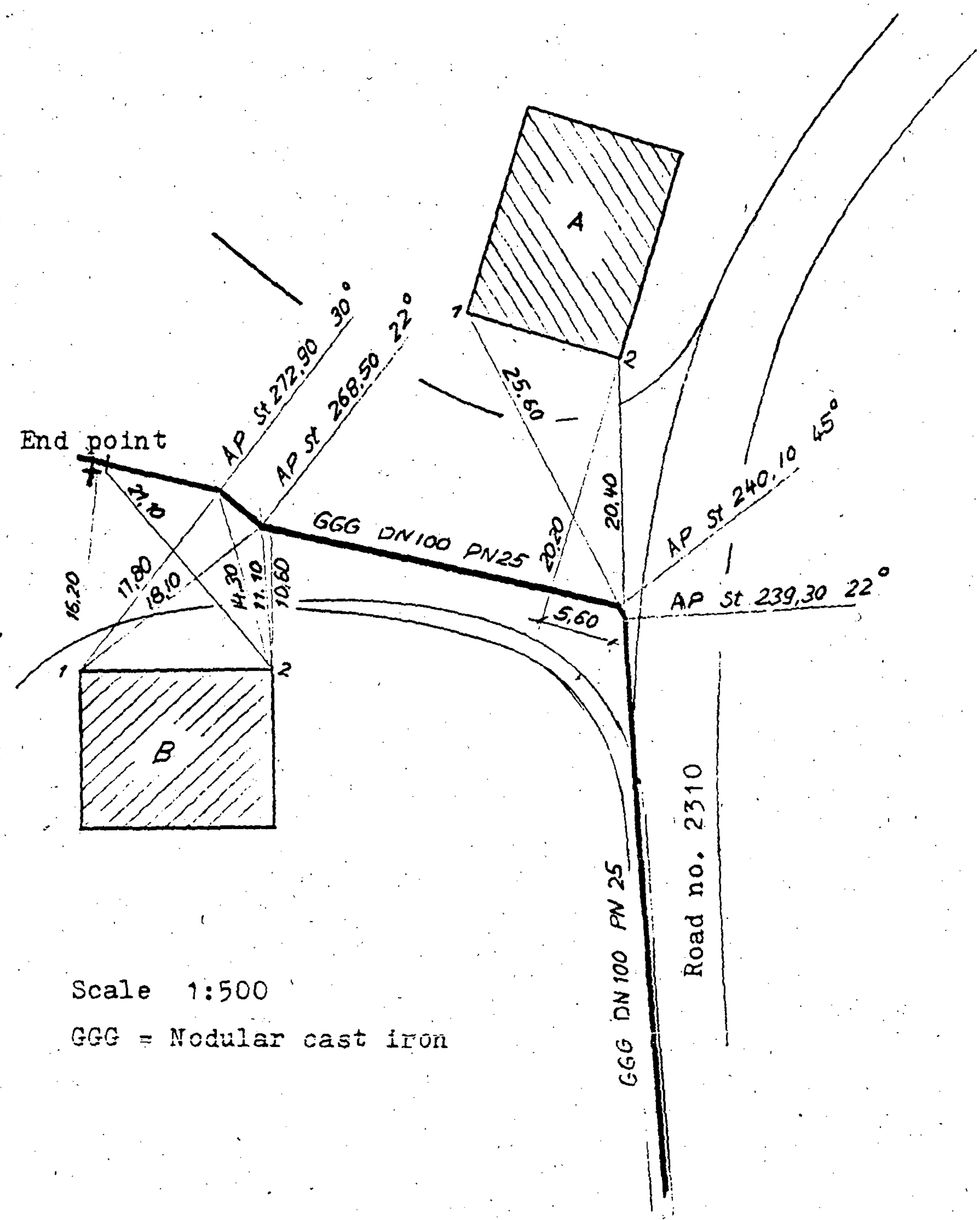


Solution to exercise 2





Solution to exercise 4



Scale 1:500

GGG = Nodular cast iron

6. Bibliography

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2. H. Solenthaler — Nivellieren für Jedermann

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4. Scholz-Grühn — Grundlehrgang Technisches Zeichnen Metall, Gehlen Bad Homburg

5. DIN standards
   DIN 4067
   DIN 2425
   DIN 2429

In some cases passages have been taken word for word from the sources quoted.

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TRAINING MODULES FOR WATERWORKS PERSONNEL

List of training modules:

Basic Knowledge

0.1 Basic and applied arithmetic
0.2 Basic concepts of physics
0.3 Basic concepts of water chemistry
0.4 Basic principles of water transport
1.1 The function and technical composition of a watersupply system
1.2 Organisation and administration of waterworks

Special Knowledge

2.1 Engineering, building and auxiliary materials
2.2 Hygienic standards of drinking water
2.3a Maintenance and repair of diesel engines and petrol engines
2.3b Maintenance and repair of electric motors
2.3c Maintenance and repair of simple driven systems
2.3d Design, functioning, operation, maintenance and repair of power transmission mechanisms
2.3e Maintenance and repair of pumps
2.3f Maintenance and repair of blowers and compressors
2.3g Design, functioning, operation, maintenance and repair of pipe fittings
2.3h Design, functioning, operation, maintenance and repair of hoisting gear
2.3i Maintenance and repair of electrical motor controls and protective equipment
2.4 Process control and instrumentation
2.5 Principal components of water-treatment systems (definition and description)
2.6 Pipe laying procedures and testing of water mains
2.7 General operation of water main systems
2.8 Construction of water supply units
2.9 Maintenance of water supply units Principles and general procedures
2.10 Industrial safety and accident prevention
2.11 Simple surveying and technical drawing

Special Skills

3.1 Basic skills in workshop technology
3.2 Performance of simple water analysis
3.3a Design and working principles of diesel engines and petrol engines
3.3b Design and working principles of electric motors
3.3c –
3.3d Design and working principle of power transmission mechanisms
3.3e Installation, operation, maintenance and repair of pumps
3.3f Handling, maintenance and repair of blowers and compressors
3.3g Handling, maintenance and repair of pipe fittings
3.3h Handling, maintenance and repair of hoisting gear
3.3i Servicing and maintaining electrical equipment
3.4 Servicing and maintaining process controls and instrumentation
3.5 Water-treatment systems: construction and operation of principal components: Part I - Part II
3.6 Pipe-laying procedures and testing of water mains
3.7 Inspection, maintenance and repair of water mains
3.8a Construction in concrete and masonry
3.8b Installation of appurtenances
3.9 Maintenance of water supply units Inspection and action guide
3.10 –
3.11 Simple surveying and drawing work

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