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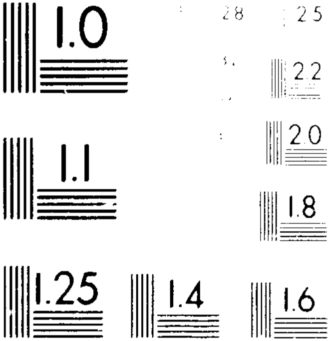

MICROCOPY RESOLUTION TEST CHART

Egypt. TRAINING PROGRAMME

BLOW MOULDING

FOR

PLASTIC DEVELOPMENT CENTRE, ALEXANDRIA.

January 28th, 1984

REPORT ON COMPLETION OF MISSION

Ref.: PRU 84-PPRF-APP/ms
Index E560856

14520

to

United Nations Development Organization
Vienna International Centre
P.O.Box 300
A-1400 Vienna/ Austria

from

Klaus Mischkowski
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West Germany

Seminar on Plastic Processing Technology (Blow Moulding)

At the Plastic Development Centre in Alexandria, Egypt during, the time from January 18th until January 27th, 1985

The time indicated includes travelling-, lecturing- and training time.

The Plastic Development Centre in Alexandria has a variety of plastic processing equipment including a blow moulding machine Type VK 1-0,7, equipped with a 50/20 D Extruder and 2 single heads to process a wide range of Blow mouldable Polymers such as PC-PP-PS-LDPE and HDPE up to approx. 1 litre capacity.

The ancillary equipment to operate the blow moulder, such as water chiller air compressor, hopper dryer and grinder are well dimensioned and in good working condition.

The Centre has also a variety of testing equipment for quality- and performance control to conduct tests established in the Blow Moulding Industry.

The staff is willing and eager to learn.

The training program attached hereto shows the latitude of the covered subjects. The program was conducted in conjunction with video movies, dia slights and overhead projector drawings as well as operating, setting, dismantling and assembling of the blow moulding machine.

The time available was actually too short to enlarge the knowledge so that the acquired technical knowhow can be passed on in confidence to other qualified operating personal of the local industry.
Therefore it is recommended that a follow up training in the future will be very fruitful to the Centre and the personal.
Due to the short time of the mission an objective impression of the organization cannot be given.

The training was separated into a theoretical part and practical part to substantiate the transmitted knowledge.
All discussed and explained subjects were shown in practical experience on the equipment.

Recommendations:

- Inadvanced organized and prepared training with a large number of participants
- Training time increase to at least 3-4 weeks, to establish confidence in the operating personal
- The centre should operate the machine on a more frequent base to enlarge the operators knowledge by running small production runs at different materials and different moulds for the industry
- For future training trial material should be provided in advance in sufficient quantity.

Every participant of the training course received a prepared folder containing the training program subject consisting of 57 typed pages written information and 64 pages in drawings, block-diagrams, curves and calculations. In total 15 training folders such as the one attached were prepared and handed out to substantiate the course.

Klaus Mischkowski

(Klaus Mischkowski)

T R A I N I N G   P R O G R A M

B L O W   M O U L D I N G

F O R

PLASTIC DEVELOPMENT CENTRE ALEXANDRIA

UNIDO PROJECT INDEX Nº E 560856

Extrusion Blow Moulding

(by K. Mischkowski)

Basic process description

The blow moulding machine is used to transform raw material polymer into a finished product.

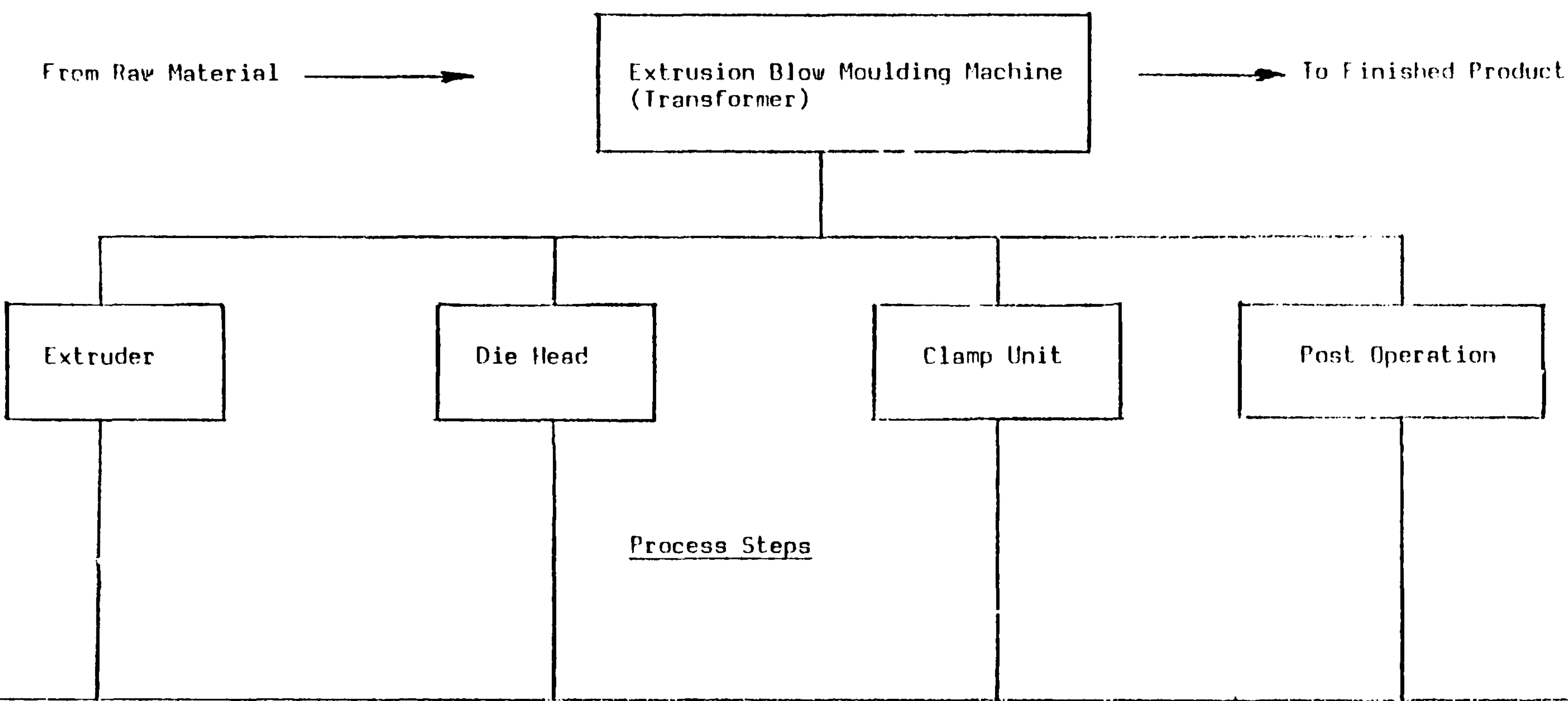
The blow moulding process consists of three or sometimes four production stages.

I. Melting and plasticizing the polymer in an extruder.

II. Forming the molten polymer into a preform or parison in a diehead.

III. Inflating the parison inside a mould with compressed air to produce an article in the moulding station or clamp unit.

IV. Deflashing and finishing the article in a post-operation unit.



Process Steps

I	II	III	IV
Plasticizing - intake, Feed - Compacting, Melting - Homogenizing, Mixing	- Directing the material flow from horizontal to vertical - Pre forming of parison	- Take over and transport of pre formed parison by the mould - Inserting air, forming and cooling of the product	- Separation of flash from finished product cutting or pushing and transport down stream

I. The extruder plasticizes the polymer from a solid state in the form of powder, grit or pellets into a homogeneous meld of a liquid state. To perform these functions, the extruder barrel is subdivided into three or sometimes four zones where the following process steps are being executed.

Intake and feed of the polymer

Compacting and melting

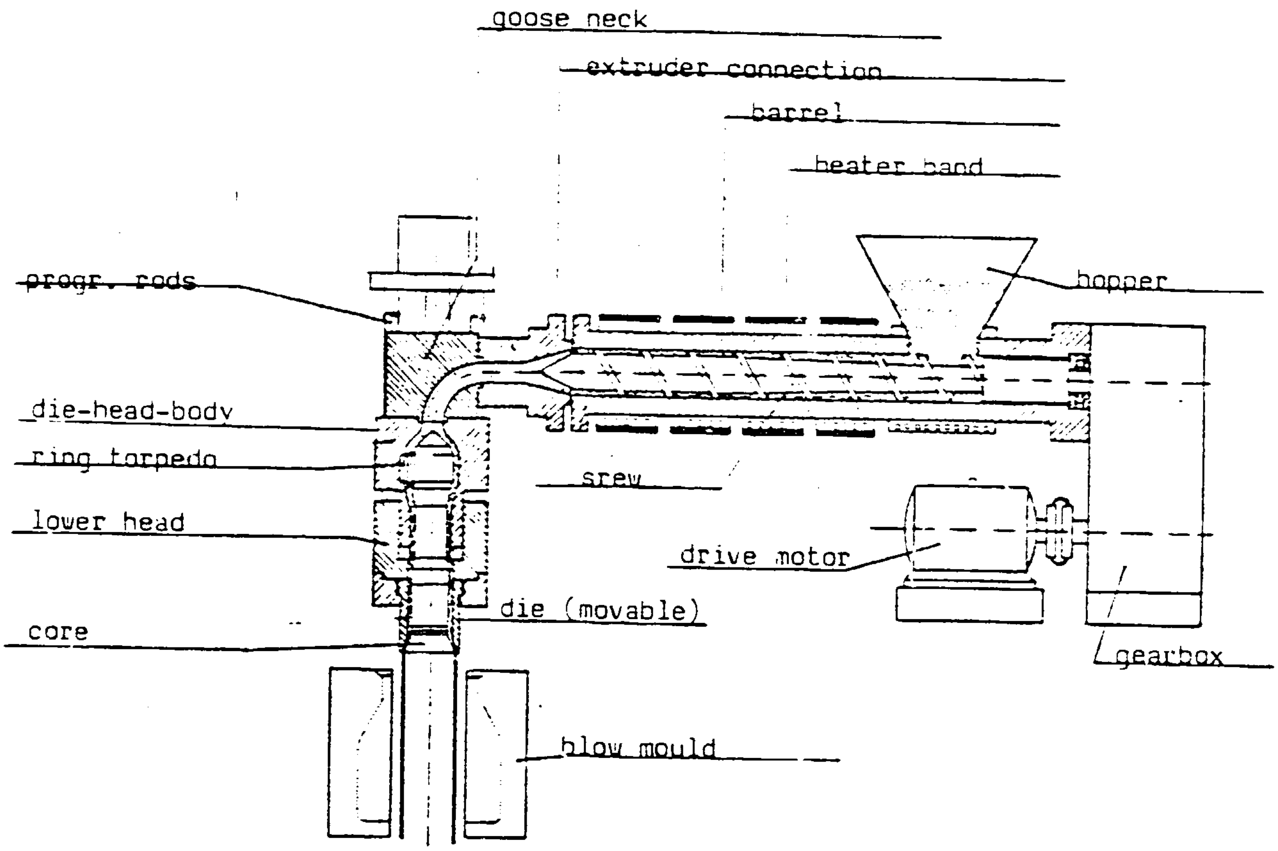
Mixing and homogenising

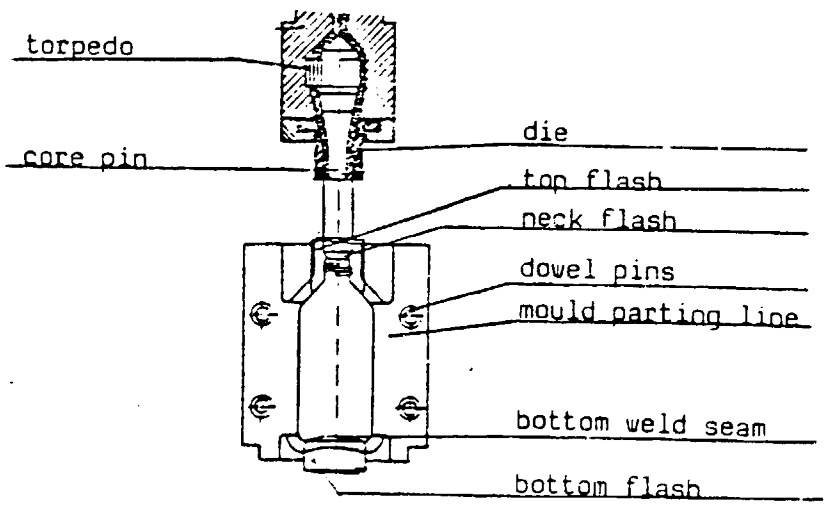
The melt is then transported by the rotating screw into the diehead.

The srew rotation moves the polymer forward. by doing so, pressure, shear, friction and heat cause the polymer to meld.

II. The diehead is so designed to direct the molten polymer from the horizontal into the vertical flow direction and shapes the meld into a flexible tube of circular cross section called parison. The parison leaves the diehead at the lower tip called dietooling.

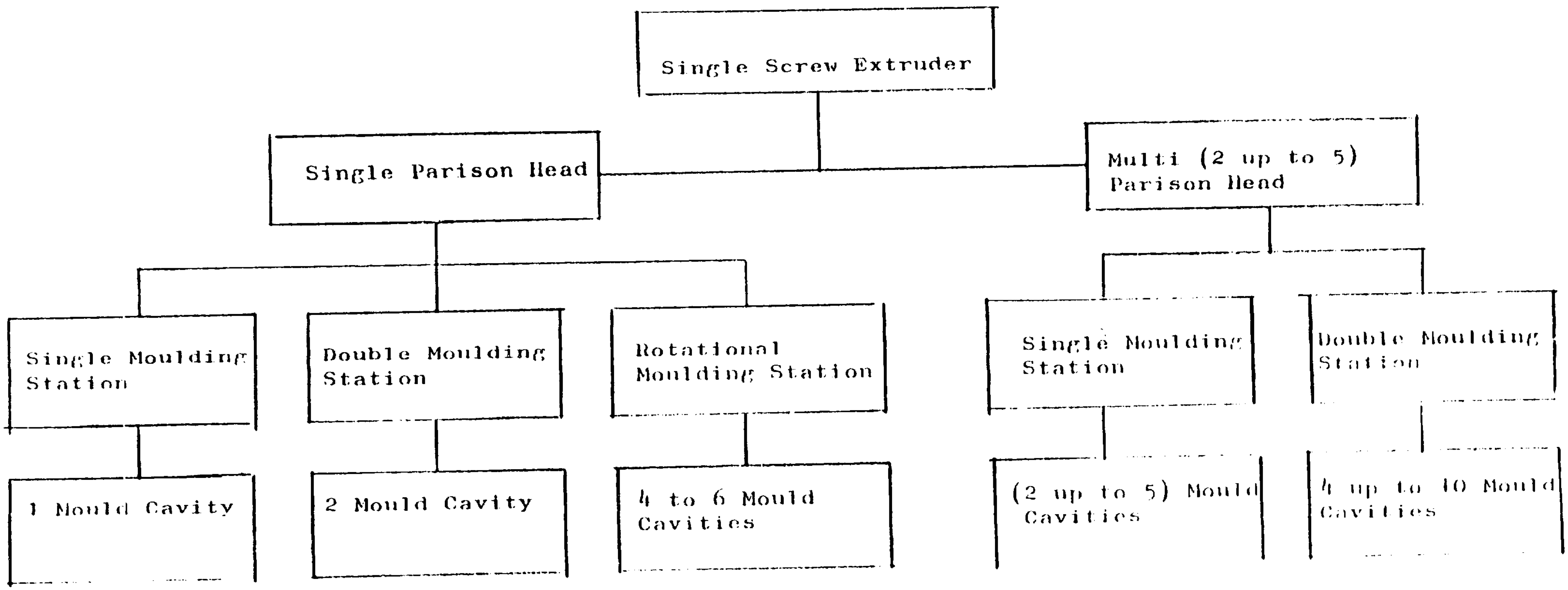
III. The moulding station or clamp unit receives and traps the parison between two water-cooled mould halves. A blowpin or needle inflates the trapped parison with compressed air. The plasticized polymer expands to the mould conture and assumes its shape. After the shaped parison is sufficiently cooled, the mould will open and the produced article is released.


goose neck
extruder connection
barrel
heater band
progr. rods
hopper
die-head-body
ring torpedo
srew
lower head
drive motor
die (movable)
core
gearbox
blow mould


torpedo
die
core pin
top flash
neck flash
dowel pins
mould parting line
bottom weld seam
bottom flash

IV. The post-operating unit (if used) receives the finished article including flash and performs post operations such as deflashing, wideneck-cutting, punching or drilling and discharges a complete finished article out of the machine upright and orientated.

COMBINATION POSSIBILITIES OF BLOW MOULDING MACHINES



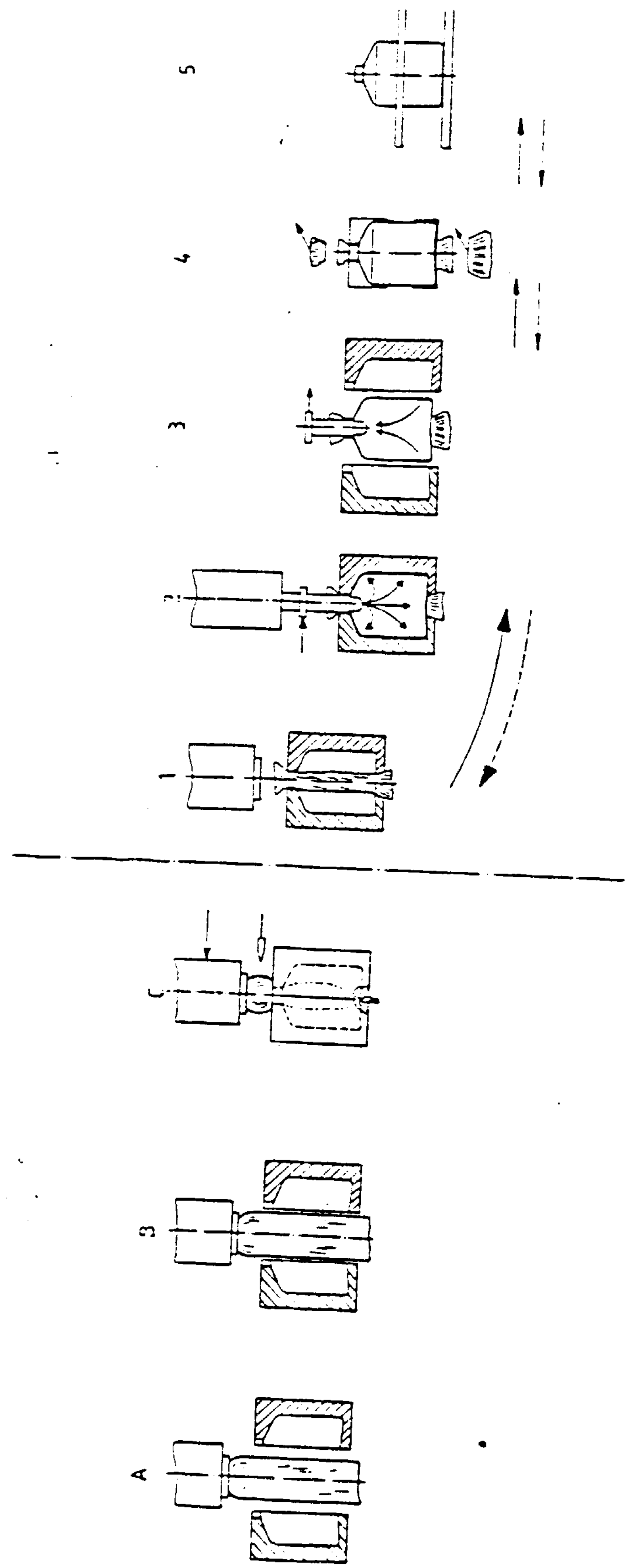
The following page shows a schematic of the blow moulding process stages.

- The plasticized parison is placed between the two mould halves.
- The mould closes around the parison, seals and pinches the lower parison end.
- Preblow air is introduced and the parison is cut and separated.
- The mould is transported toward the blowing station.
- Air is blown into the mould.
- At the end of the blow time, the container pressure is released.
- The mould opens.

Generally, all blow moulding machines are operating this way. Regardless if they are continous extrusion or accumulator head machines with intermitten parison ejection.

If a post-operation station is used, the article including top and bottom flash is transported by the next cycle into the post-operation position to be deflashed.

The following transport stroke will transport the completely finished article downstream out of the blow moulding machine.



Blow Moulding Processing Steps

Blasformen: Produktionsschritte

Extruder: (principle)

The extruder can be looked at as being subdivided into the extruder drive and the extruder barrel assembly.

The extruder drive consists of:

- drive motor with speed variation
- the speed reduction geer box
- the trust-bearing assembly, housing the screw-receiving shaft.
- Operating and control circuitry.

The extruder drive motor must have a variable speed to turn the srew slower or faster in order to match the required parison length to the moulding cycle.

If the moulding cycle increases, the extruder RPM must also be increased to produce the same parison length within a shorter time and vice versa.

In general, three different extruder drive executions are being offered:

- Three-phase ac motor combined with a pulley-belt drive.

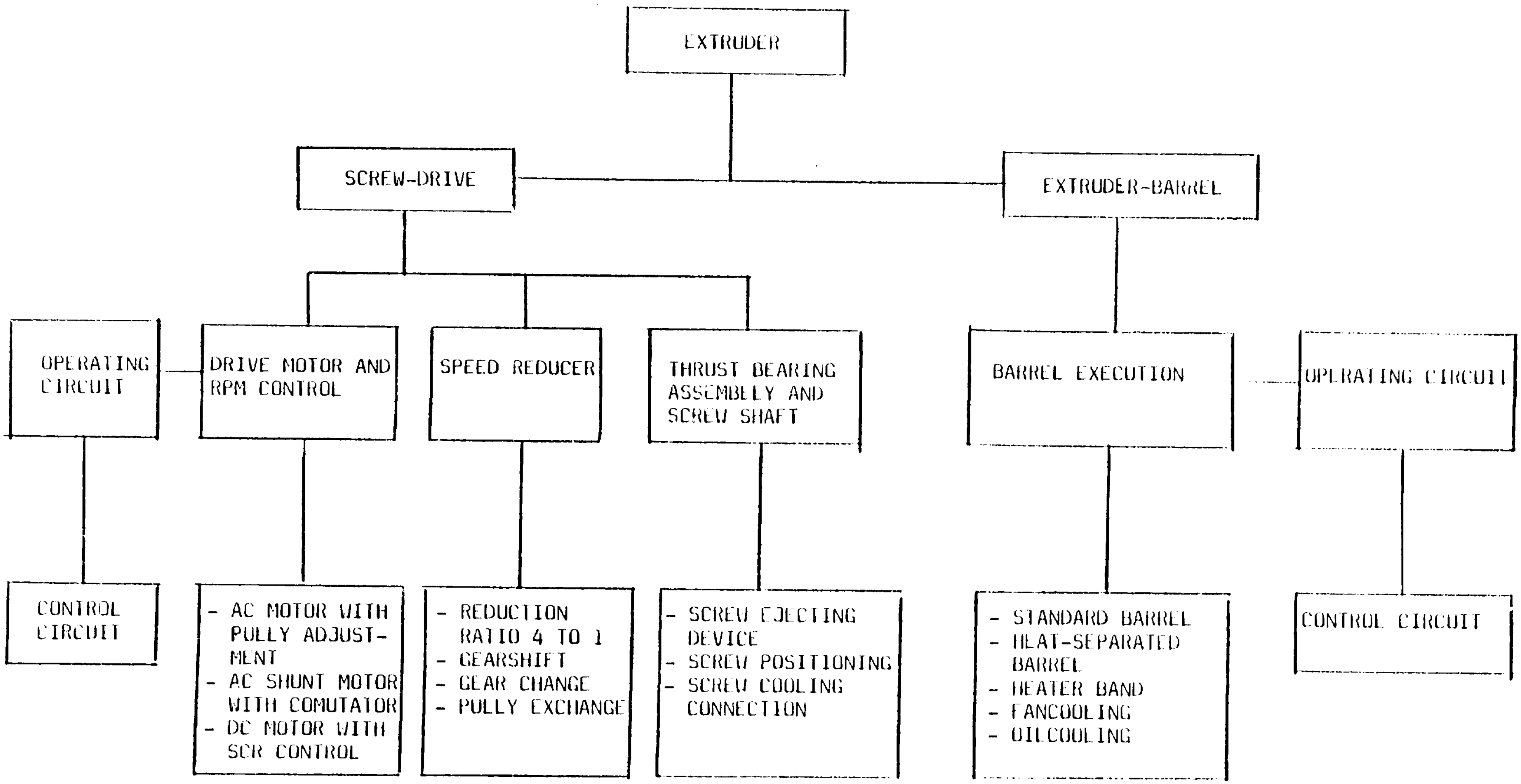
The motor turns at the given RPM, the speed regulation is performed by the mechanical changing of the pulley-distance and diameter.

- Three-phase shunt wound ac motor where the speed is regulated by moving brushes on the commutator either clockwise or counterclockwise to change the field voltage supply, thereby regulating the speed.

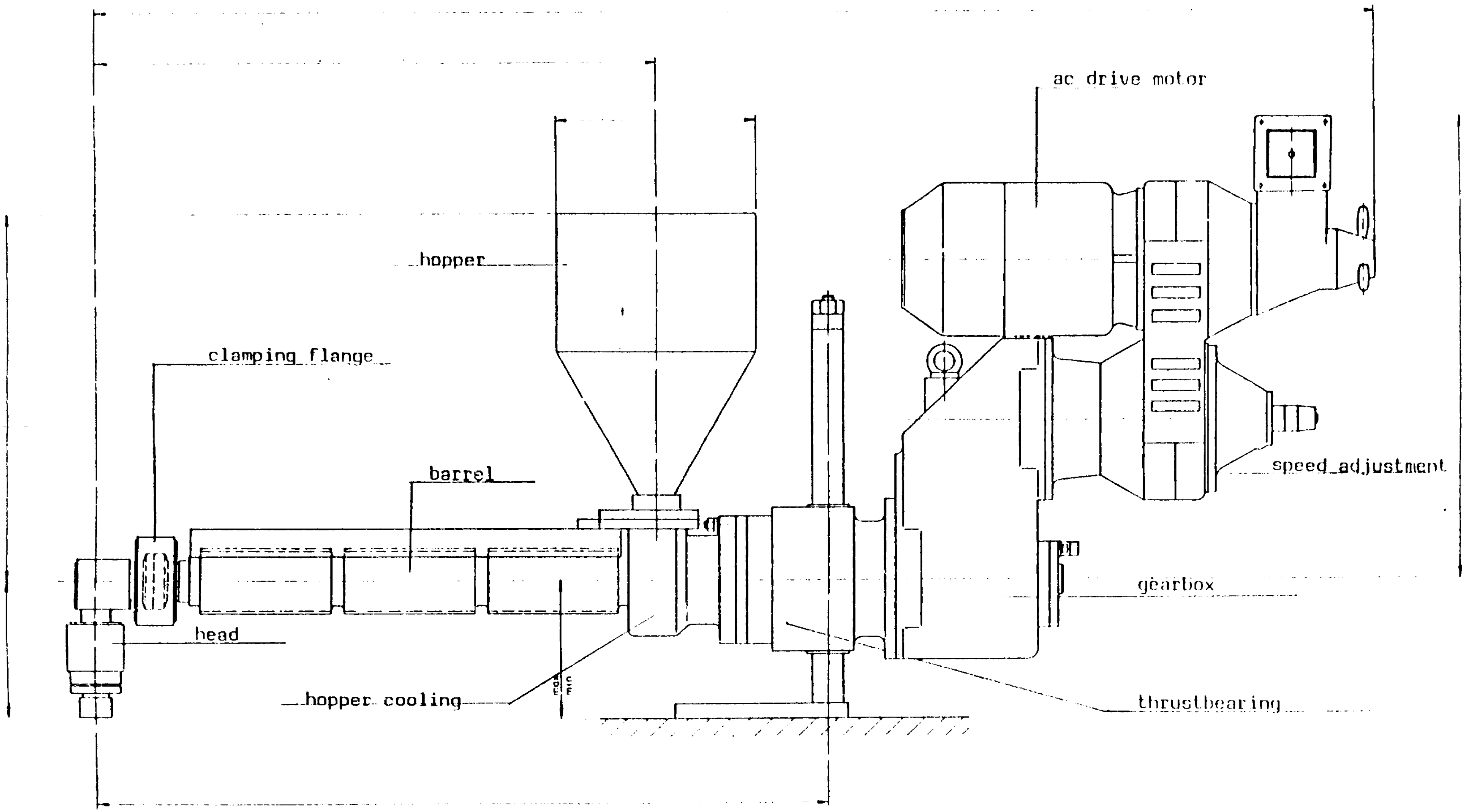
- Dc drive motor with an SCR unit to rectify the three-phase AC into DC voltage. The speed here is regulated by changing the field voltage supply via a potentiometer.

All three extruder drives´ executions have a constant drive torque over the complete speed range.

This is absolutely necessary in extrusion blow moulding to avoid parison surging or fluctuation.



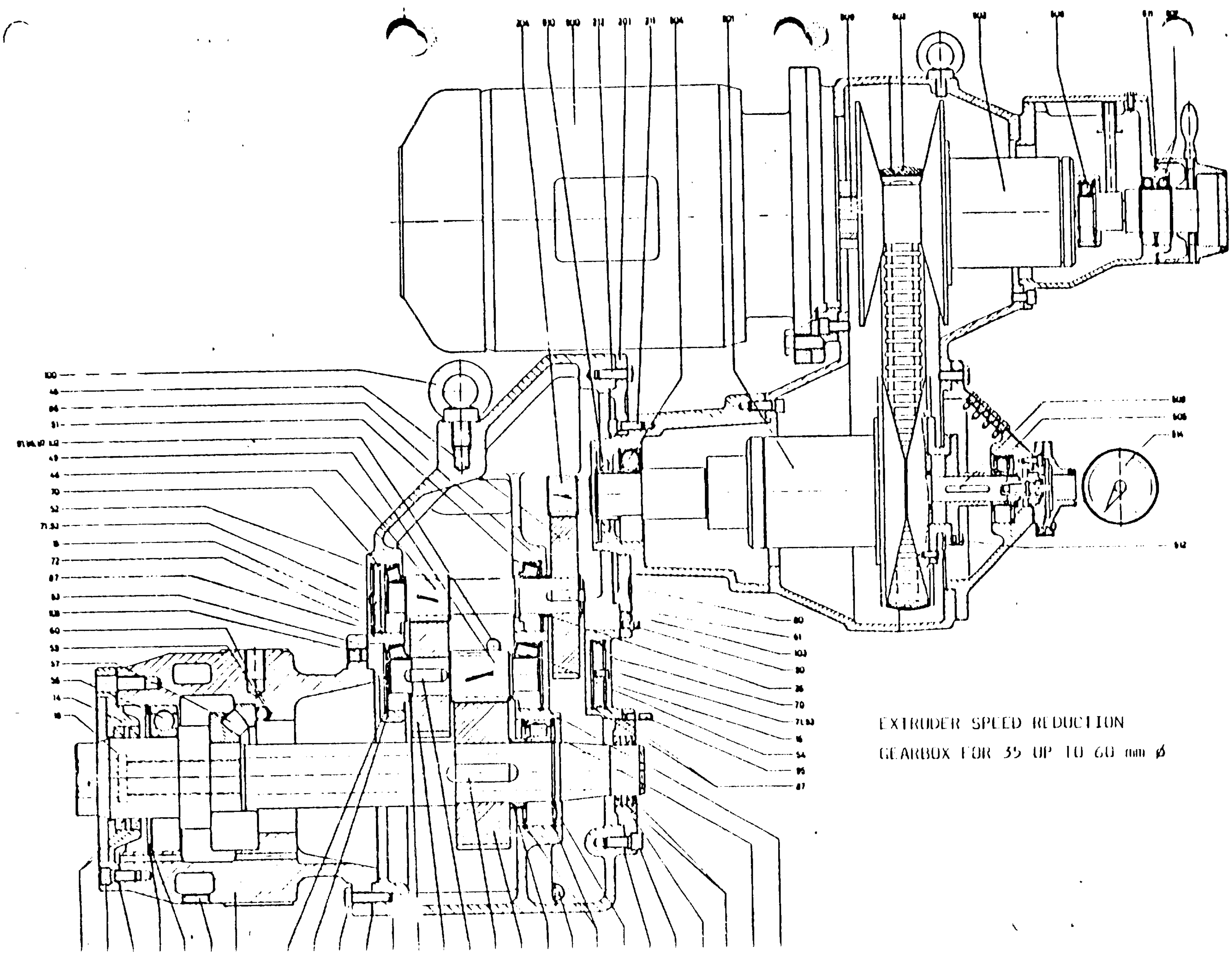
EXTRUDER
SCREW-DRIVE
EXTRUDER-BARREL
OPERATING CIRCUIT
DRIVE MOTOR AND RPM CONTROL
SPEED REDUCER
THRUST BEARING ASSEMBLELY AND SCREW SHAFT
BARREL EXECUTION
OPERATING CIRCUIT
CONTROL CIRCUIT
- AC MOTOR WITH PULLY ADJUST-MENT
- AC SHUNT MOTOR WITH COMUTATOR
- DC MOTOR WITH SCR CONTROL
- REDUCTION RATIO 4 TO 1
- GEARSHIFT
- GEAR CHANGE
- PULLY EXCHANGE
- SCREW EJECTING DEVICE
- SCREW POSITIONING
- SCREW COOLING CONNECTION
- STANDARD BARREL
- HEAT-SEPARATED BARREL
- HEATER BAND
- FANCOOLING
- OILCOOLING
CONTROL CIRCUIT



EXTRUDER 35 UP TO 60 mm ø

The speech reduction geer box changes the relatively high RPM of low torque from the drive motor into a slow RPM of high torque. Modern speed reduction geer boxes have helical or hering bone geer transmissions with splash lubrication. To connect the drive motor onto the geer box, a direct tension-free coupling or v-belts are used. If the v-belts are employed, the drive motor is mounted onto a adjustable base to allow belt-tension adjustment for slip-free-belt tension. An attached RPM generator provides the voltage for the RPM indicator usually situated at the operator console.

The thrust-bearing assembly houses the outer race of the self-aligning roller bearing. The inner race is situated at the srew receiving shaft. The srew is slipped into the two keys fastened in the inner shaft bore. When the srew turns and transports the polymer forward a back pressure is created on the srew shaft. This back pressure is taken by the thrust-bearing to allow the srew shaft to turn tension free.



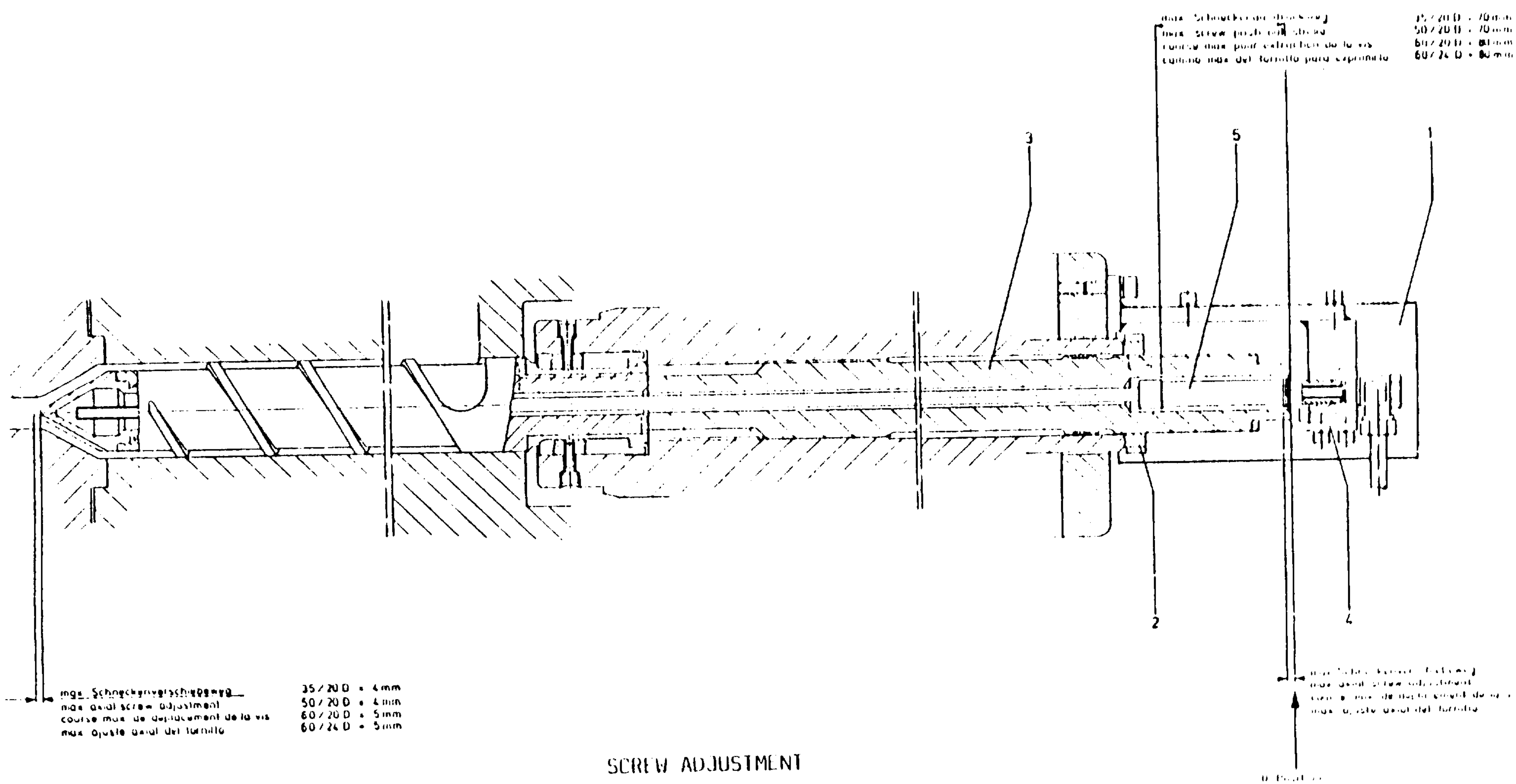
EXTRUDER SPEED REDUCTION
GEARBOX FOR 35 UP TO 60 mm ø

The srew receiving shaft has a bore inside to house a srew adjusting rod. This adjusting rod serves two purposes - as a srew ejecting device and - as a srew positioning device.

For processing pvc and other heat-sensitive materials srew positioning adjustment is required but not for other polymers. When pvc or policarbonate is being processed, the srew will create different back pressures depending upon the gap between the 60° srew cone (tip) and the matching head adapter. Is the gap between srew tip and head adapter large, then the created back pressure is relatively low. By moving the srew-positioning rod forward (maximum not further than the metering srew flight depth), the back pressure increases. In doing so, the material flow towards the head is restricted and the residence time of the polymer is prolonged. During that time, more energy and mixing is put into the polymer.

The srew adjusting rod has a hole in the center to allow an internal srew cooling pipe to be placed inside. By processing pvc, frictional heat is also created at the srew root. This heat must be removed by blowing cooling air through this center onto the srew tip, then escaping backwards to the outside. The cooling pressure required is usually between 1-3 bars.

The srew cooling pipe should end approximately 6 to 8 millimeters before the screw tip.



SCREW ADJUSTMENT

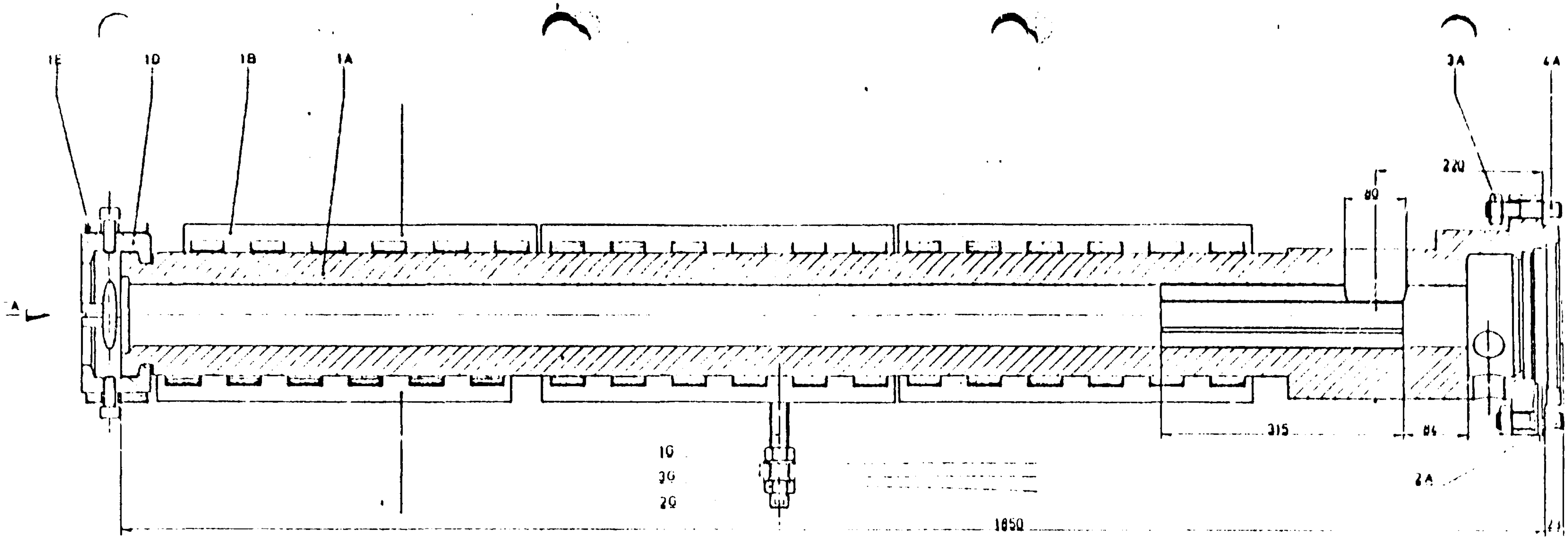
SCREW EJECTING DEVICE

Extruder barrel assembly

In general, two different barrel designs are used to process a wide range of blow mouldable polymer.
The standard design is used to process PVC, PC, PS, LDPE as well as HDPE and consists of a straight barrel flanched onto the extruder geer box.

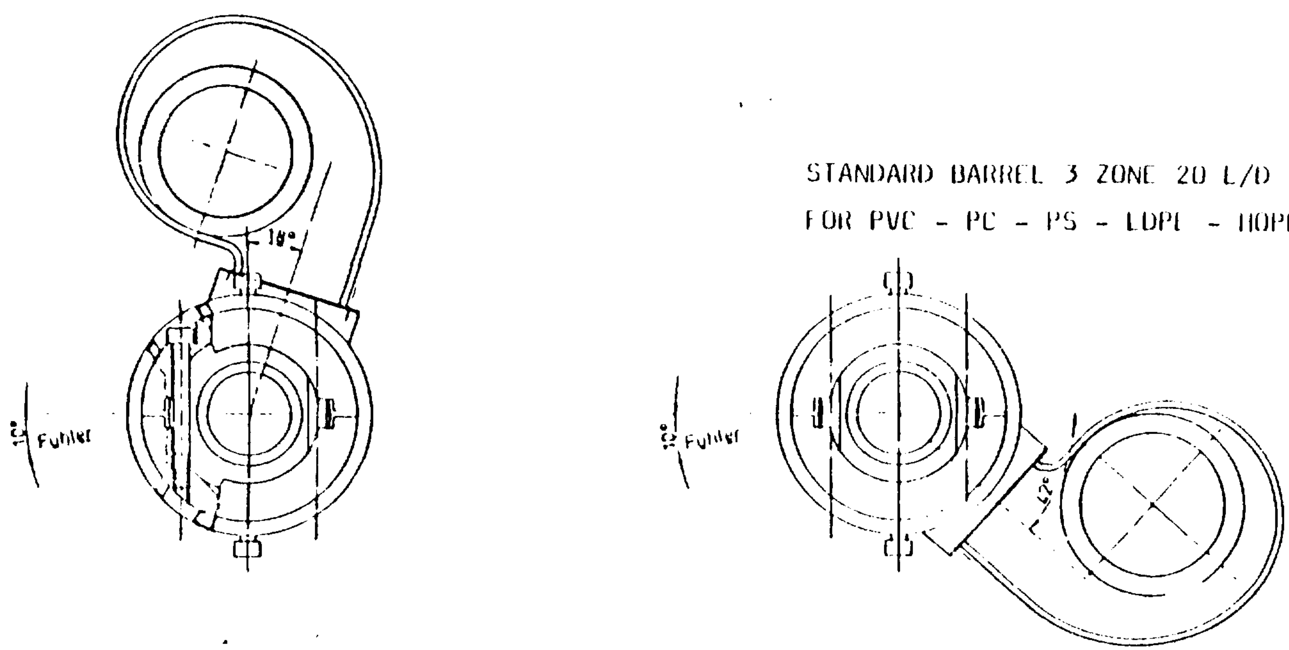
In the feed zone, the barrel is equipped with flat conical grooves, reaching into the middle of zone no.1. These grooves are important for a constant material intake. The extruder barrel length for blow moulders is 20 times the internal diameter of the bore, mesured from the front end of the feed opening to the barrel end. For processing PVC, however, sometimes 24 L/D ratios are being used in order to increase the output rate.
All thermoplastic polymers are very bad heat conducters. So it requires a certain residence time, while the polymer is travelling from the material feeding throat to the srew tip to become homogeneously plasticized.
Is the residence time shortened by increasing the extruder RPM, the polymer reaches the srew tip faster before being completely molten and mixed. By adding one zone of 4 L/D onto the barrel, the residence time is prolonged and the polymer is completely homogenized by leaving the srew tip. This in turn requires a stronger drive motor to overcome the additional required torque on the srew shaft.

The srews employed in conjunction with this barrel type are three-zone srews with a relatively deep feed section in the rear and a shallow metering section in front. The srew part in between is a constant taper.



STANDARD BARREL 3 ZONE 20 L/D

FOR PVC - PC - PS - LDPE - HDPE WITH FAN COOLING

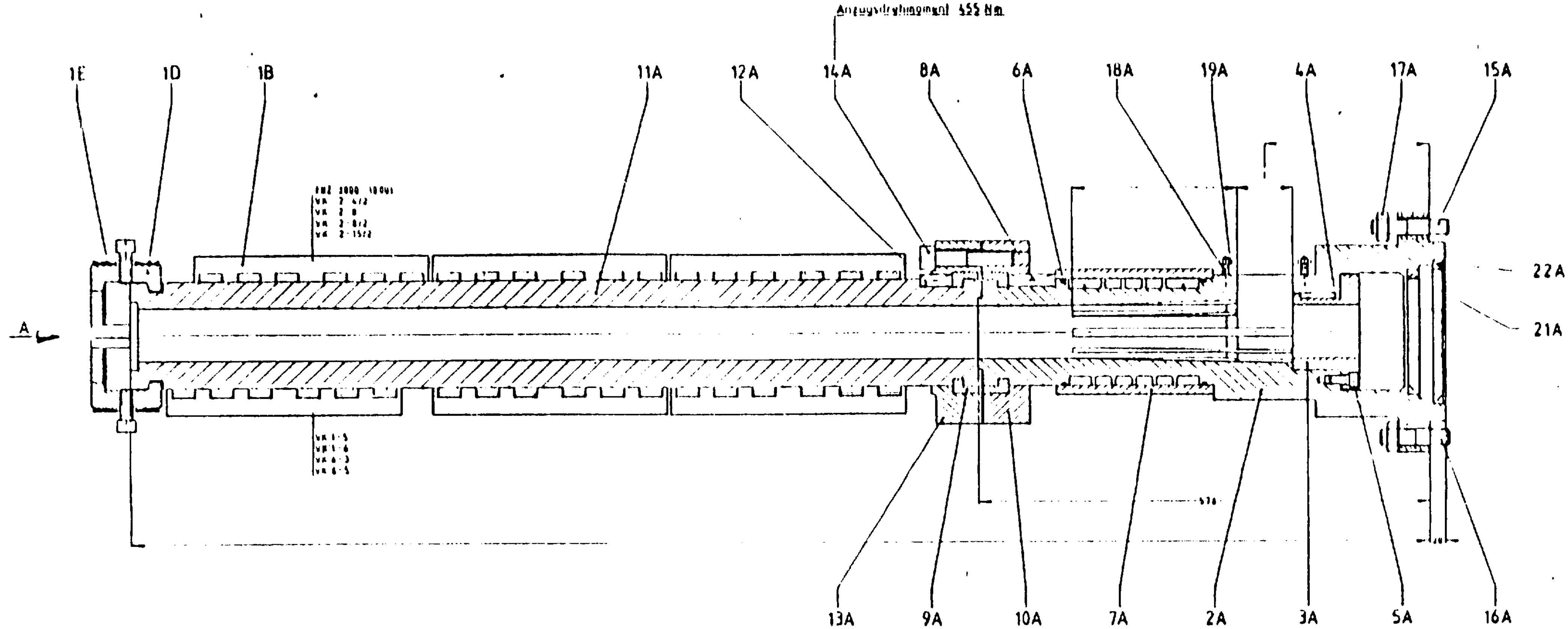


The heat-separated barrel is especially designed to process HMWPE, PP, LDPE and HDPE in the form of powder, grits or pellets.

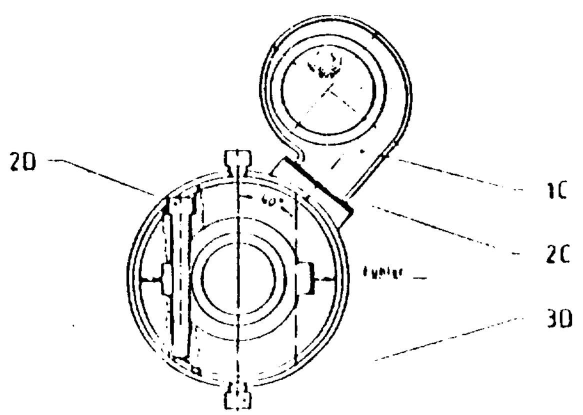
The extruder barrel is separated in a cooled feed section and a heated, compacting, melting and mixing section. There is a air gap insulation in between these two sectons to avoid a heat or cooling interchange-ability.

This set-up is necessary to process the above mentioned polymer correctly.

The srew employed in conjunction with the heat separated barrel is relatively shallow, all the way from the feeding section to the srew tip. As mentioned before, thermoplastic polymer is a very poor heat conducter. As the srew flights are kept shallow, the material layer in between the barrel wall and the srew root is relatively thin and can therefore be influenced better by the heat to become plasticized. The minimum residence time of a polymer in the extruder barrel is given by the maximum RPM of the extruder srew. Therefore, there is only a restricted time span available to plasticize a given polymer layer. Shallow screw flights create a shallow material layer, but the material intake at the feet zone is very poor. Deep srew flights take in more material but create a thick material layer, which will not plasticize in the residence time available. Also the back pressure created by the flow restriction toward and inside the head will influence the constant material intake and flow. The heat separated barrel design combines all positive and eliminates all negative aspects as mentioned before.



Ansicht A



HEAT-SEPARATED BARREL 3ZONE 20 L/D
FOR HMWPE, PP, LDPE AND HDPE

The material intake or feed section has deep conical grooves on the inside circumference of the barrel. These grooves are getting shallower toward zone no.1. The complete feet section is intensively water-cooled. The material feed process can be explained as follows:

The turning srew takes the material in and compacts the polymer in the grooves by forcing it forward to the evershallower groove section, thus creating pressure and compacting the material. The screw rotation creats internal shearing resistence on the groove edges, so the material cannot escape or slip on the barrel wall. The cooling supports this action by not allowing the shearing to create heat and therefore eliminating the shearing force. This combination of action creates two major results: a) consistent high volume material intake with a shallow flighted screw; which b) is independent of any back pressure variations.

Extruder power and control circuit

If a three-phase ac motor is used, an overload switch protects the drive motor for being overloaded or single-phased.

An ac shunt motor changes its ampere load in the same way as the RPM changes. Therefore, a normal overload cannot be employed to protect the motor. A special secondary current protection is required as well as a thermal protection switch, situated at the motor casting to stop the motor if the temperature approaches a dangerous level.

Dc motors are protected by the design of the SCR unit to assure a long troublefree operation. The extruder must always be started at the lowest RPM range. Therefore, the control circuit is designed in such a way that the motor always returns automatically to its minimum RPM, after being switched off. By restarting, a preset acceleration time brings the motor to the selected RPM range.

Extrusion screws

The extrusion screw transports the polymer from the extruder feed zone through the diehead. It is the most important part of the extruder.

Most companies have their own screw design developed. An extensive amount of research and development work including long-term trial runs are involved until the best suitable screw is developed. The aim is to have one screw to process a wide range of polymers.

Extrusion screws have three basic sections:

- feed section
- transition section
- metering section

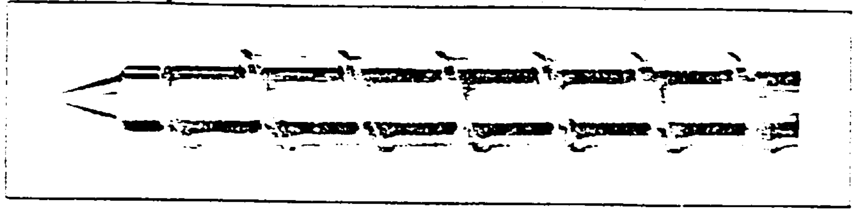
In the feed section, the material is taken in and compacted in conjunction with the feeding grooves at the rear of the extruder barrel. It supplies the compression section with a constant polymer flow.

In the transition section, friction heat is generated, the material is molten and plasticized. Any entrapped air from the feed zone will escape backwards.

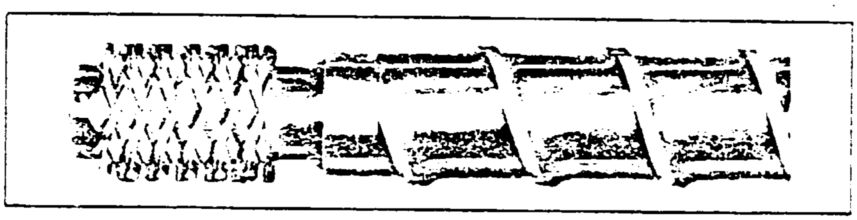
The metering section mixes and homogenizes the polymer. At the screw tip, the material should be completely homogeneous and ready for the next processing step in the diehead.

In extrusion blow moulding, a 20:1 L/D ratio is used as a standard, to increase the output rate a 24:1 ratio can also be employed.
The L/D ratio is the srew length divided by its diameter. Screws to process different materials have also different compression ratios.
The compression ratio (CR) is generally referred to as the depth of the feeding zone flight compared to the depth of the metering zone flight. Compression ratios range from 1.1 : 1 up to 3.5 : 1 for different screw designs.

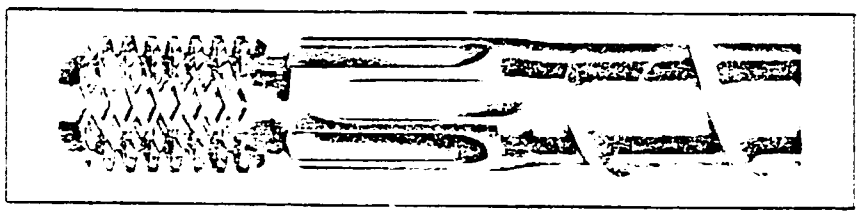
In the following we illustrate the more common types of screw:



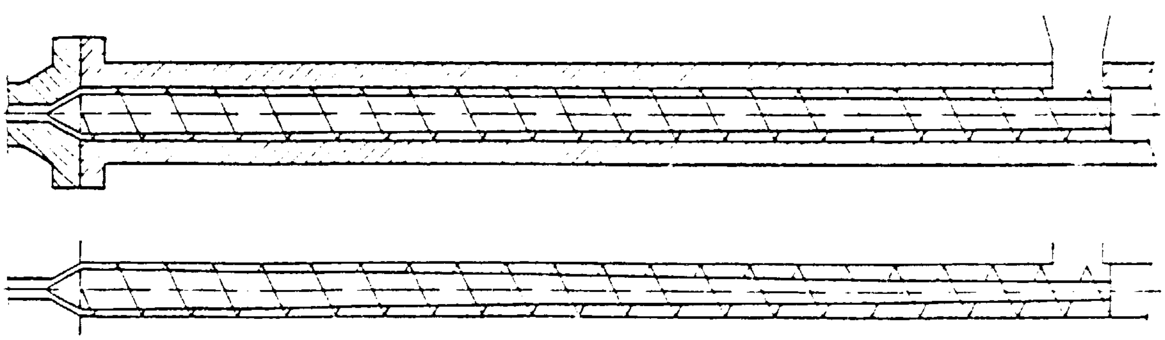
Ill. 25: **PVC screw** for the processing of PVC in powder or granular form. Also suitable for processing PC, PS and PA and restrictedly for soft PVC.

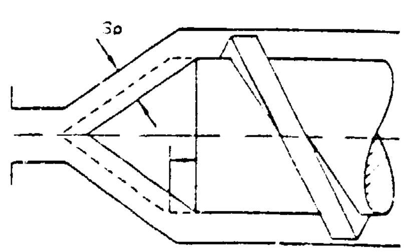


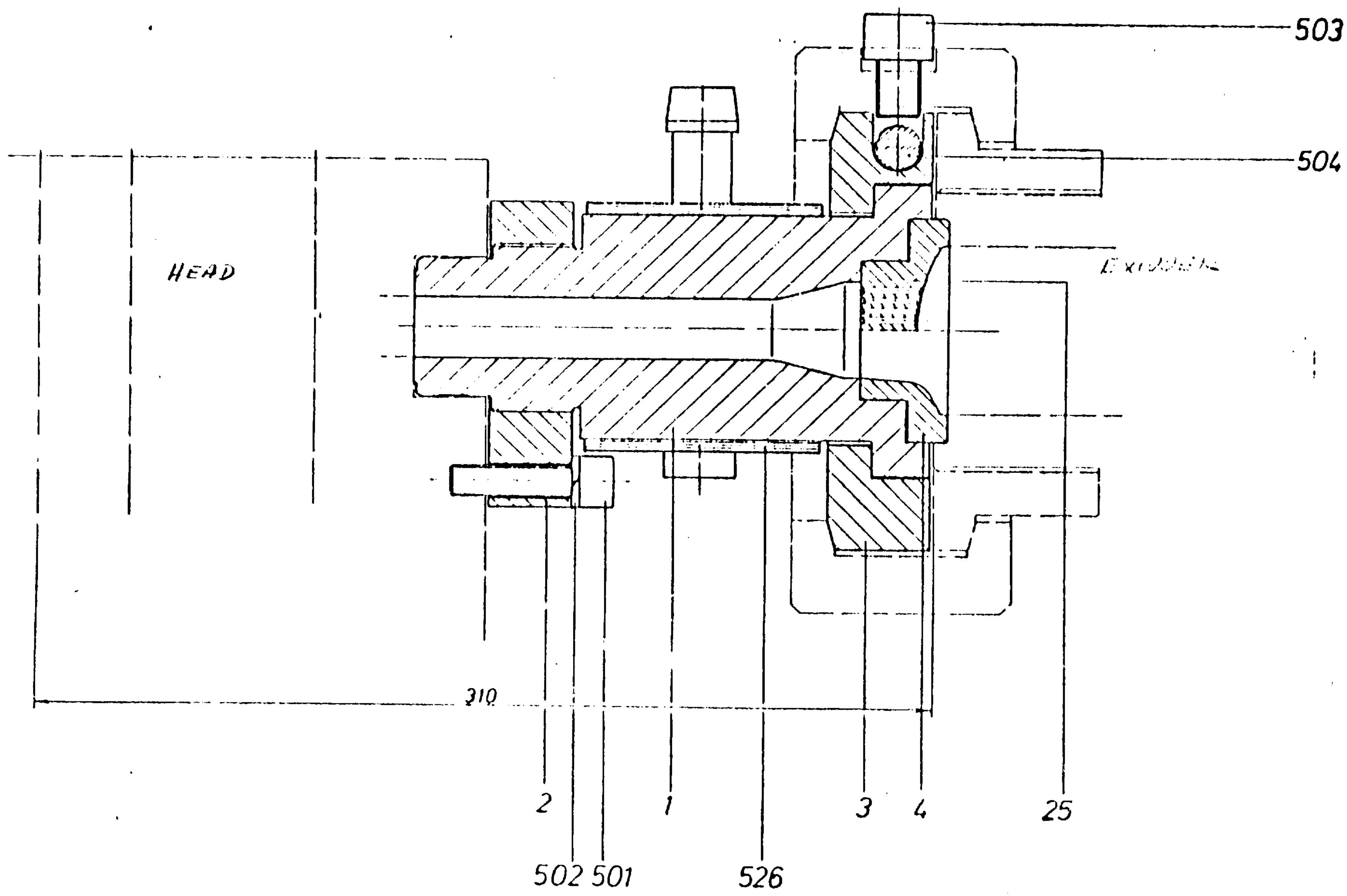
Ill. 26: **Standard PE-screw** for conventional extruders for processing high density and low density PE. This is also suitable for the processing of PS and for PP with reservations.



Ill. 27: **PE-screw** for use in heat separating insulated extruders. It is capable of processing all polyolefines incl. high molecular PE.







EXTRUDER CONNECTION
WITH BREAKER PLATE

Dieheads

Dieheads are usually referred to as continuous extrusion heads compared to accumulator heads for discontinuous material ejection.

There are basically two different head designs in use,

- center-fed and
- side-fed heads.

The different designs are illustrated on the following page.

The newest technology is the center-fed head, here the melt flows vertically downwards and around the inner core.

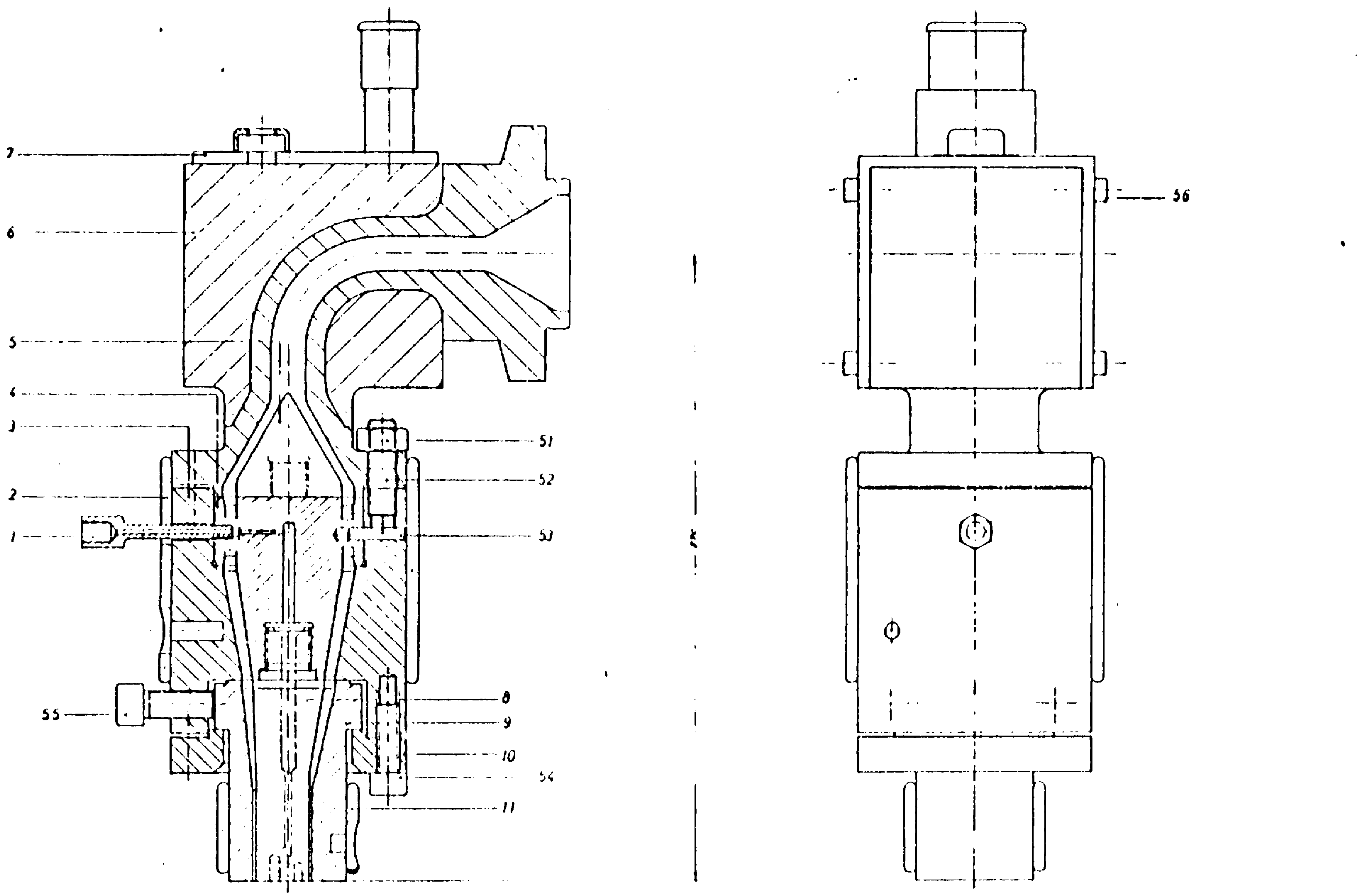
This design characteristic gives a uniform material flow and an equal polymer distribution on the parison circumference. The streamlined material flow has no dead areas, so the polymer residence time in the head is given.

PVC dieheads are center-fed heads with two spiderlegs to hold the inner torpedo in its position. The two spiderlegs are positioned into the parting line of the mould for one simple reason, should the reknitting lines become visible then they match the parting line of the container and are not detectable. In the PVC head, the polymer flow from the extruder passes the goose-neck which changes the flow direction. The torpedo is equally covered by the material flow. The two streamlined spiderlegs split the material flow and a choke zone underneath is designed to support the reknitting or rewelding of the polymer flow behind the spider legs. From there, the downward polymer flow is continuously pressurized until the parison emerges out of the dietooling. The preblow air is brought through one of the spiderlegs to blow air inside for supporting the plasticized parison during cutting and/or avoiding it from collapsing.

Task: Die heads change the polymer flow from horizontal to vertical and from the homogenized polymer from the extruder into a turbular parison. They are subbivided into three categories to process a wide range of polymers with different caracteristics.

Die Heads

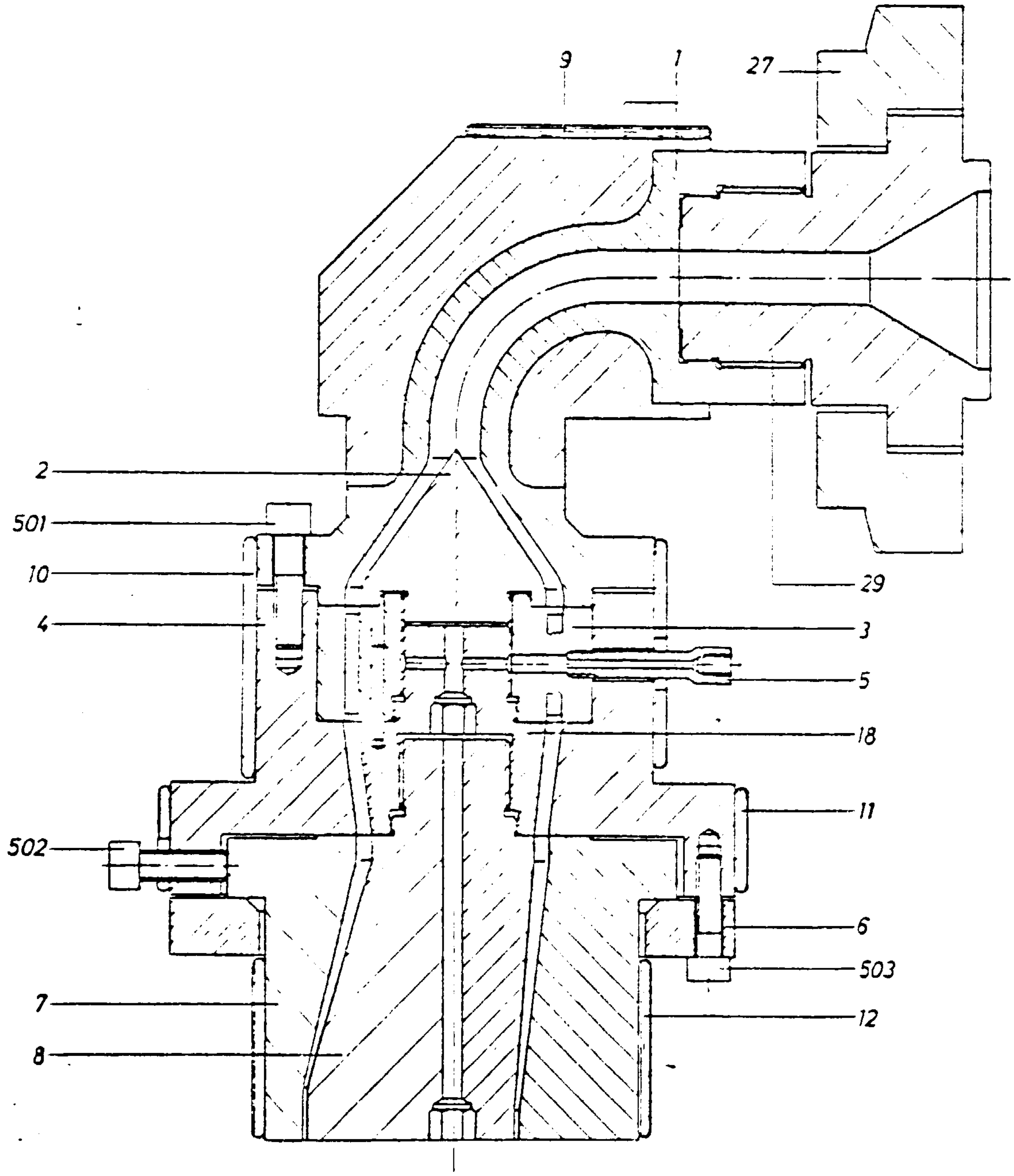
Torpedo Head	Mandrel Head	Double Spider Head
Polymers to be processed		
PVC PC	LDPE-HDPE PS, (PP)	HMWPE PDPE-HDPE PS PP
Design Features		
Central Material flow on to a two leg spider Torpedo Streamlined flow channels	Material flow sideways into reknitting curve High pressure build-up for equal material distribution around inner mandrel	Central material flow on to a double ring spider with overlapping reknitting sections and pressure shoke zone
Executions		
single-double	single to quadruple	single to triple
Pre Blow Air Connection		
Sideways through spiderleg	Through center of inner mandrel	Siedeways through outer and inner spider ring



PVC HEAD
(FOR BOTTLE PRODUCTION)

PVC DIE HEAD

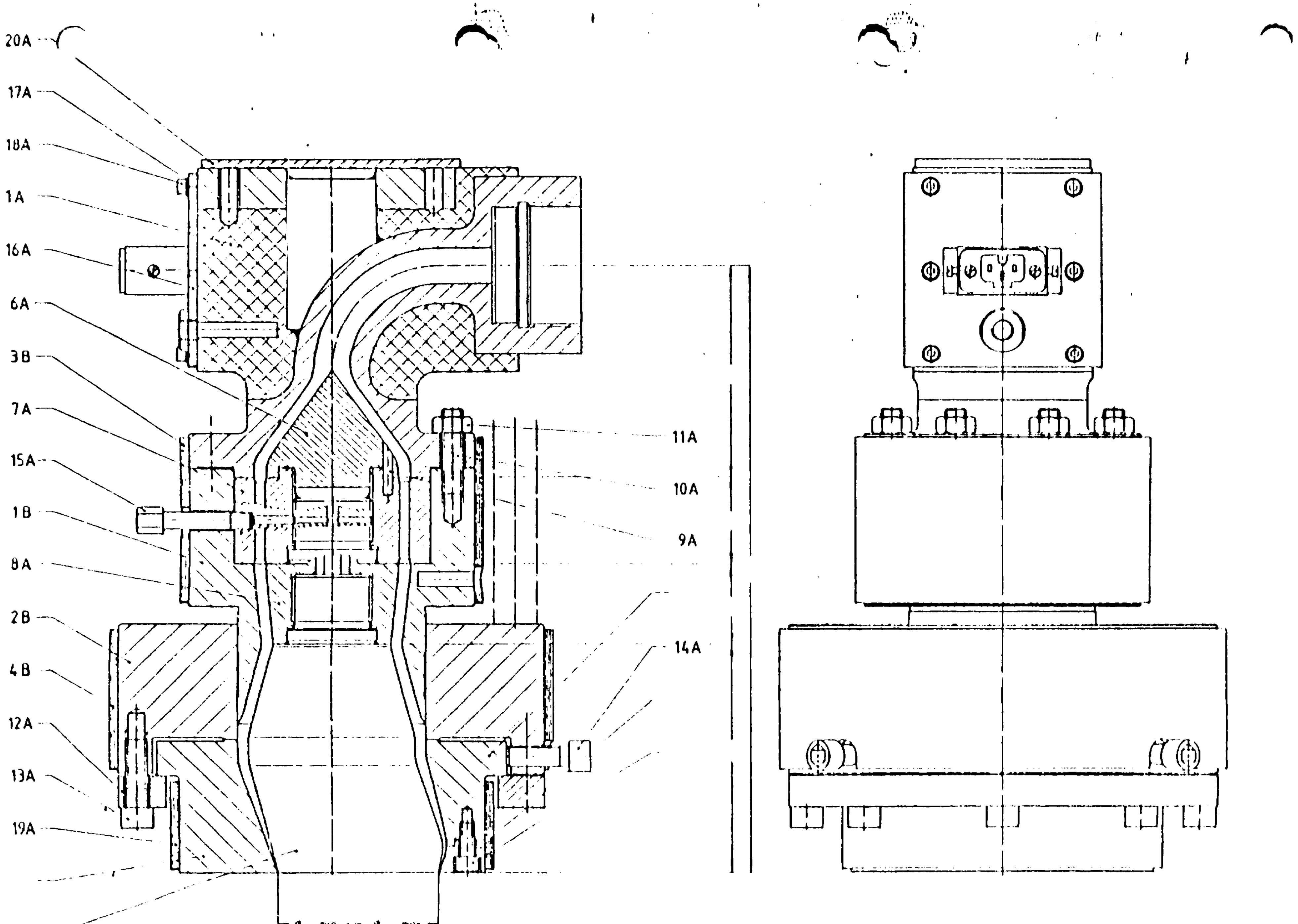
(NON PROGRAMMABLE)



max. diameter

min. diameter

FOR HANDLE CONTAINERS UP TO 5 l



PF RAMMABLE PVC HEAD

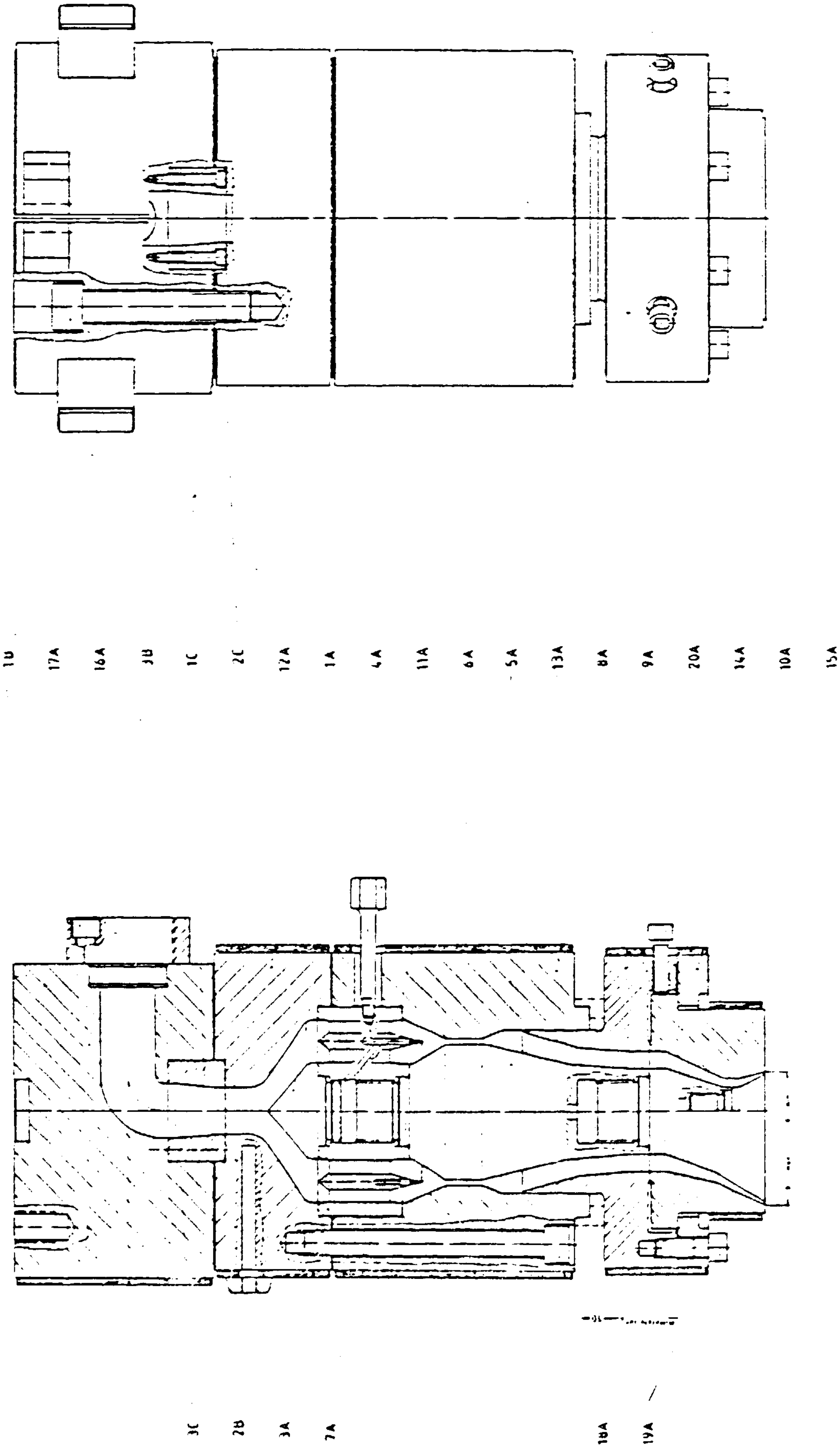
Double-ring spider heads

This head design is used to process HMWPE, PP, and a wide range of low and high density PE.

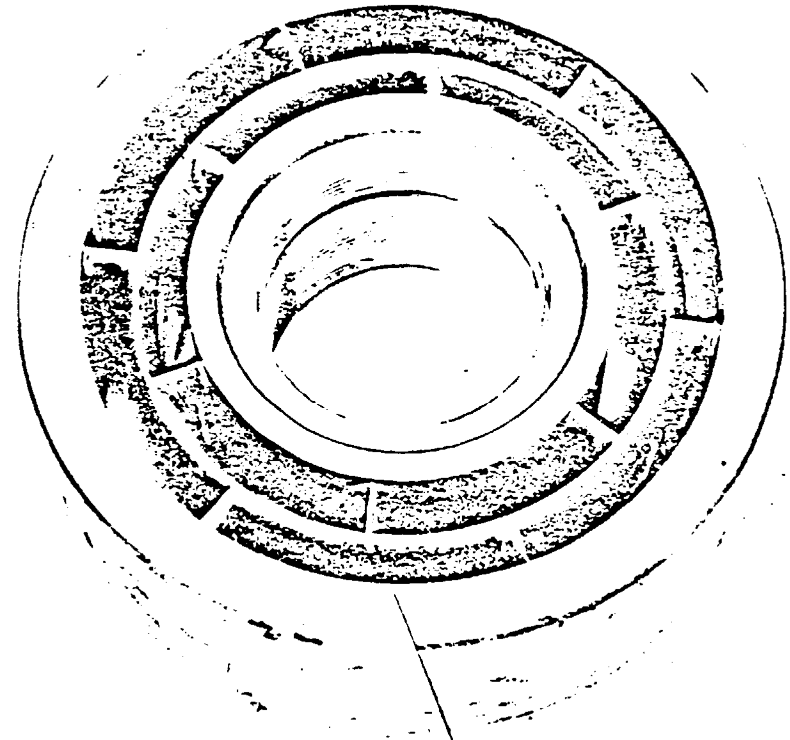
Here, the material flow is also diverted by 90° to flow vertical onto the double-ring spider torpedo. The polymer is split up over the torpedo in two separate material layers. One inner and one outer layer overlapping each other. Both layers are being rejoined behind the spider by a choke zone where the material is compressed to recombine.

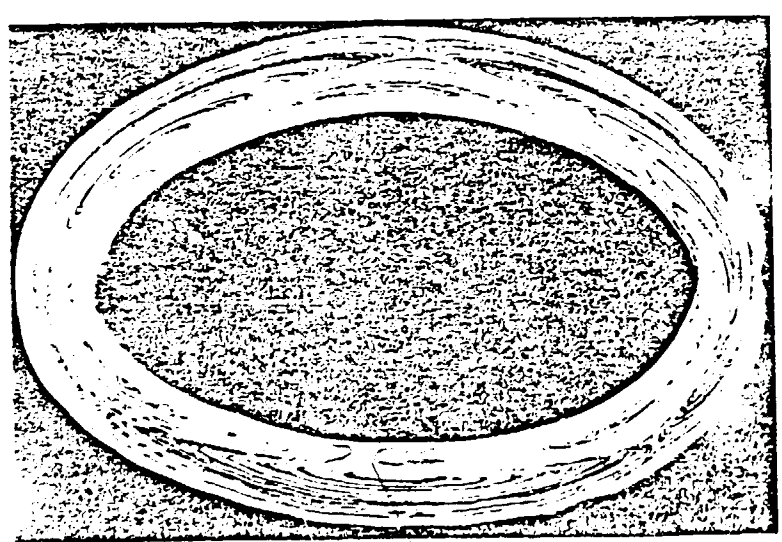
This system where a strong layer of material covers a thin reknitting area behind the spiderleg gives a strong and even polymer distribution on the parison and consequently on the finished product circumference.

The preblow air is brought through one outer and one inner spider, inside the head it supports the parison during extruding and cutting.



SINGLE DIE HEAD WITH DOUBLE RING TORPEDO

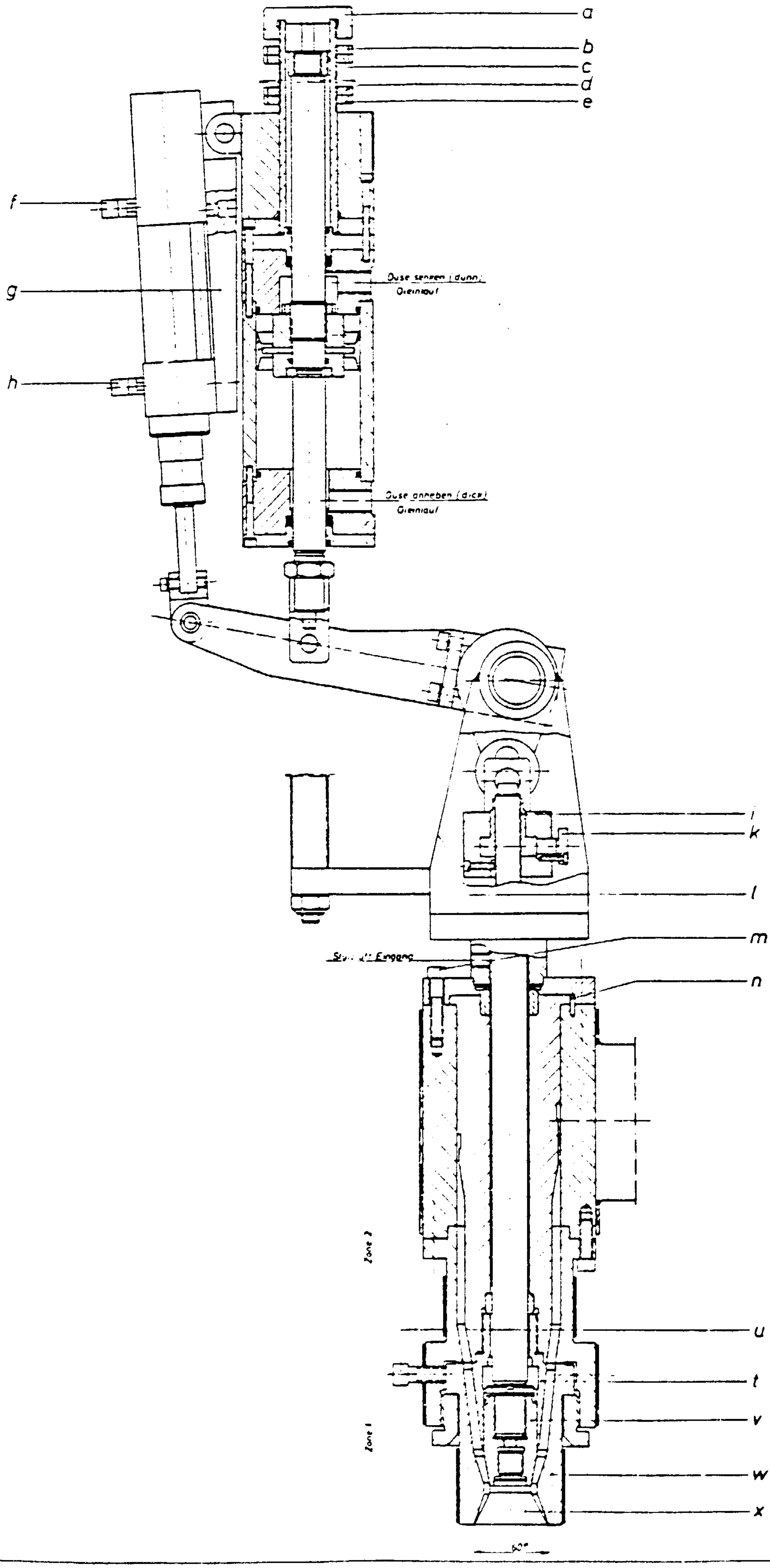




[redacted]

The mandril head is a side-fed head and is used to process low and high density PE. This is the earlier design not too sophisticated and also less expansive to manufacture. However, the material distribution for large blow-up ratios above 1:4 is not good enough for today's standard. The recombining or reknitting of the material flow opposite the feeding side is supported by a so-called hard curve. The material enters the head on one side, flows around and downwards the inner mandril. The hard curve is a milled-in slot of special design situated opposite the material entrance to force the material to reknit.

The head design does not allow an overlapping of this weak spot to compensate it. The preblow air is connected through the center of the mandril inside the parison.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Zone 1
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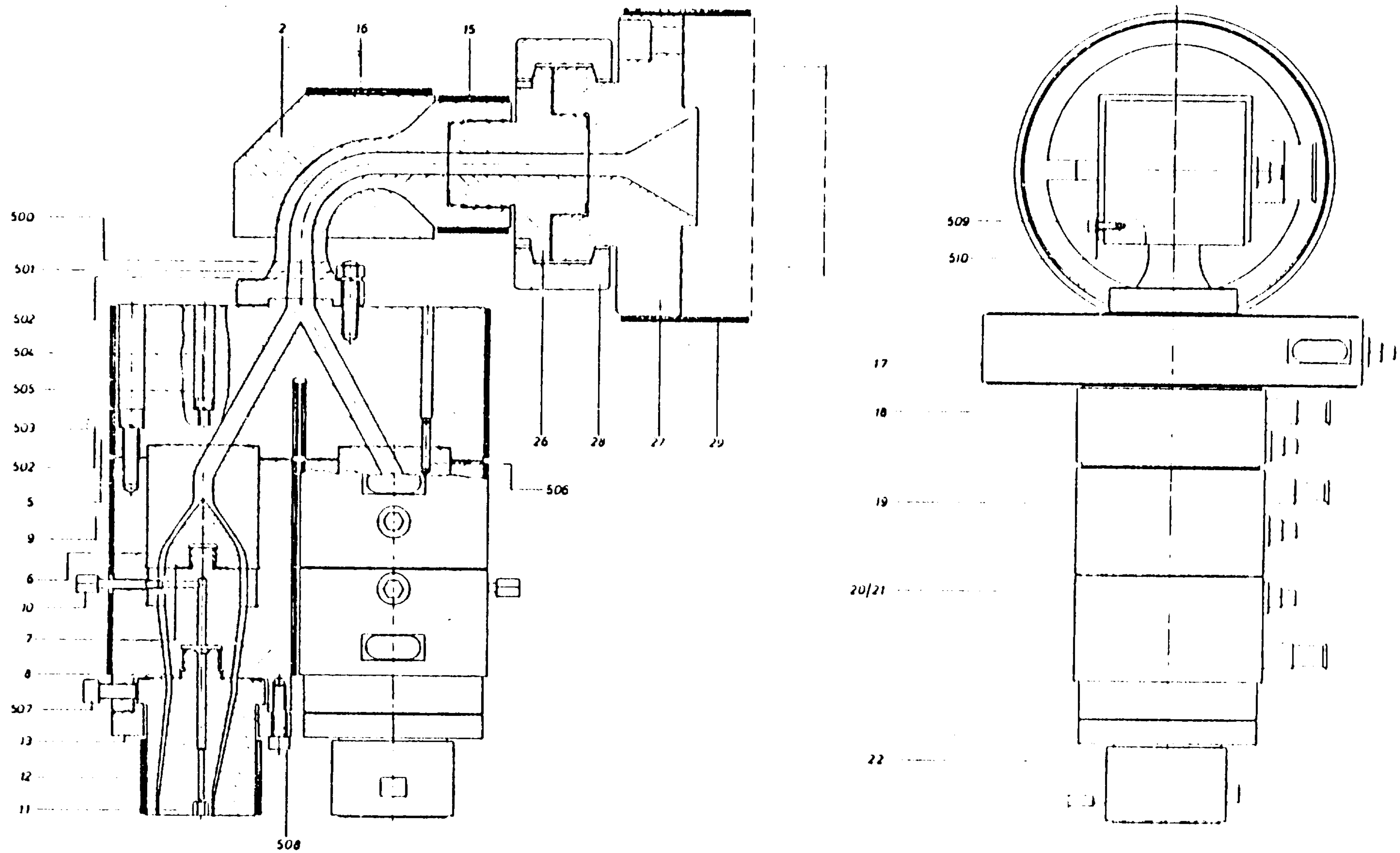
60°

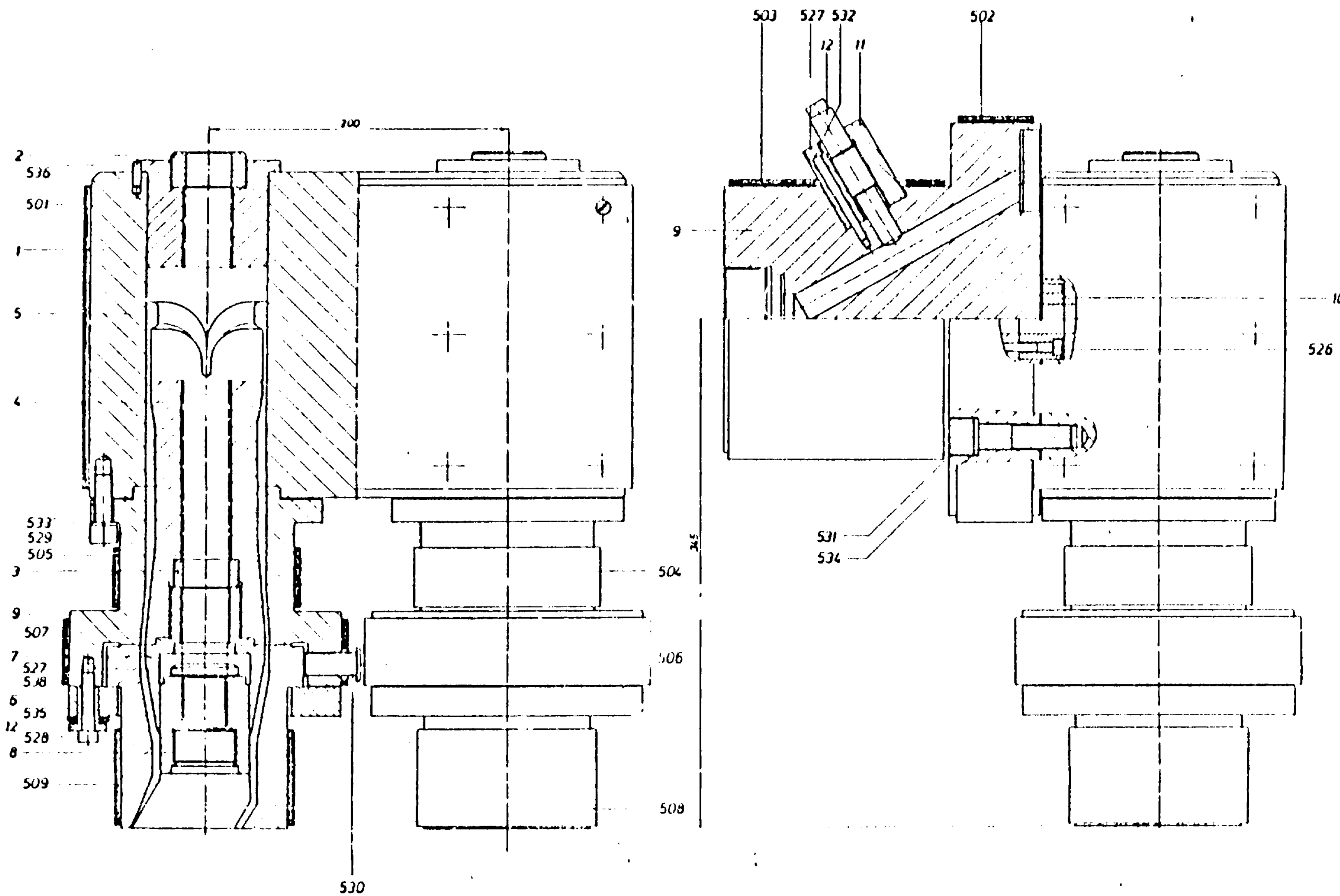
Multiple heads

Up until now, only single parisons being extruded were considered. Obviously, a single parison is easier to control in its length and its circumferece as multiparisons. The maximum number of heads in commercial blow moulding is five in parallel. Each parison is controlled individually in flow and pressure built up to have the same length, wallthickness and consistency. The polymer flow from the extruder is divided in a manyfold block where the single channels to each head branch off. Each flow channel into the single head has a flow control or throttle valve to regulate the incoming material flow.

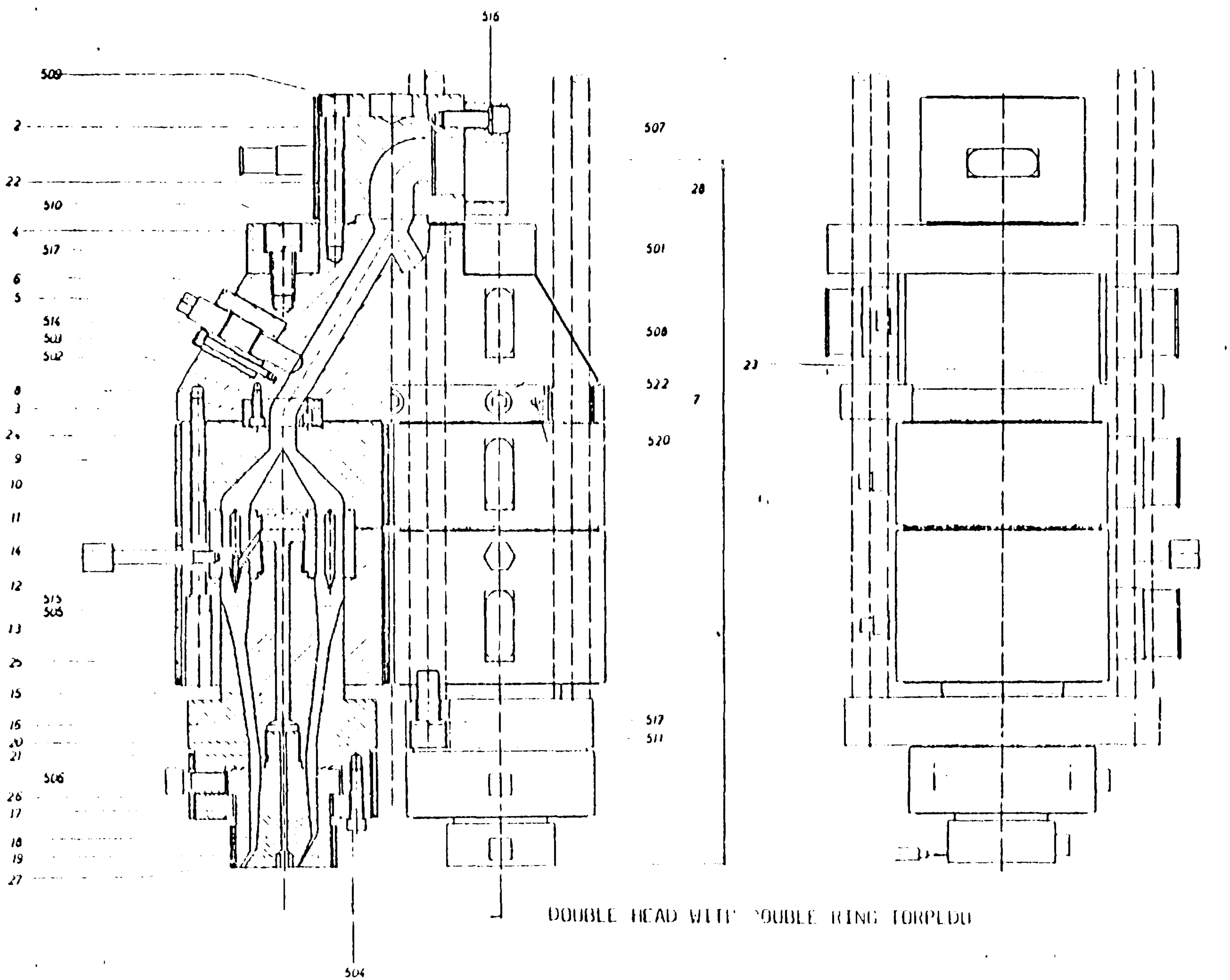
For multiple PVC head production a double head is the most common practice. There are a few triple and quadruple heads in the field, however, they need a very close set-up and attention. Multiple PVC heads have no mechanical flow control. They require a streamlined flow pass to avoid material hang-ups. A prolonged residence time inside the head would decompose or burn the PVC polymer. Equal parison length and weight is controlled by the head temperature setting. A lower temperture on one side of the head will cause more flow resistence and therefore a shorter emerging parison, whereas a high temperature has the adverse effect.



PVC DOUBLE HEAD



DOUBLE HEAD MANDREL DESIGN

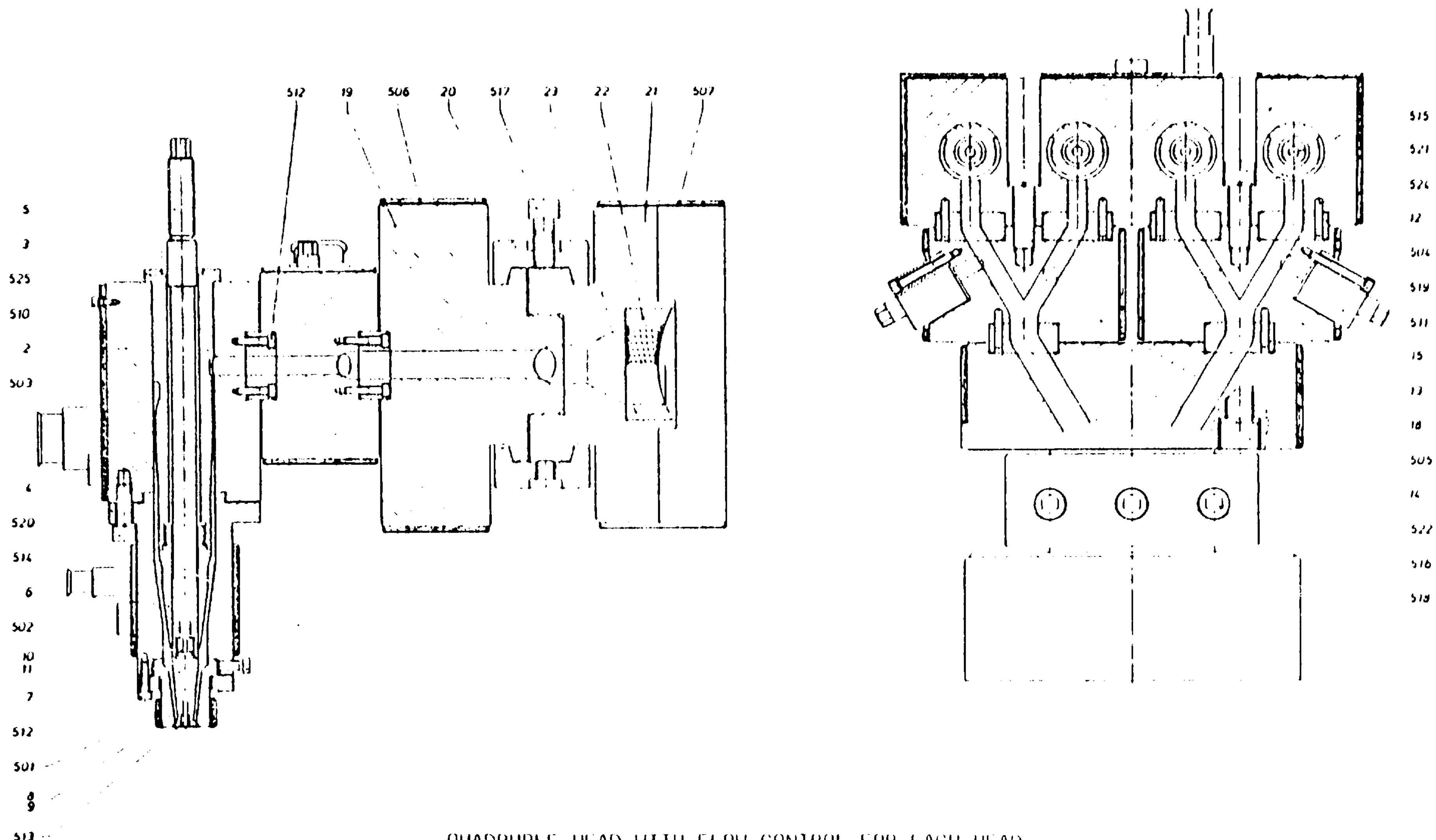


DOUBLE HEAD WITH DOUBLE RING TORPEDO

Parison flow control adjustment

In order to be able to control an equal parison length on each parison of the multiple head a flow control or throttle valve is provided. Since the die head closer to the pressure source (extruder) receives more material than the one further away, the pressure difference is compensated with the throttle valve adjustment. Thus all individual parison heads receive the same amount of material. The throttle valves are adjusted as follows:

During the initial start-up all flow control valves should be open. When the extrude turns at a given production speed to produce the correct parison length and wall thickness, the longest or fastest running parison is being thottled, each head at a time until all emerging parisons have the correct and consistent length.

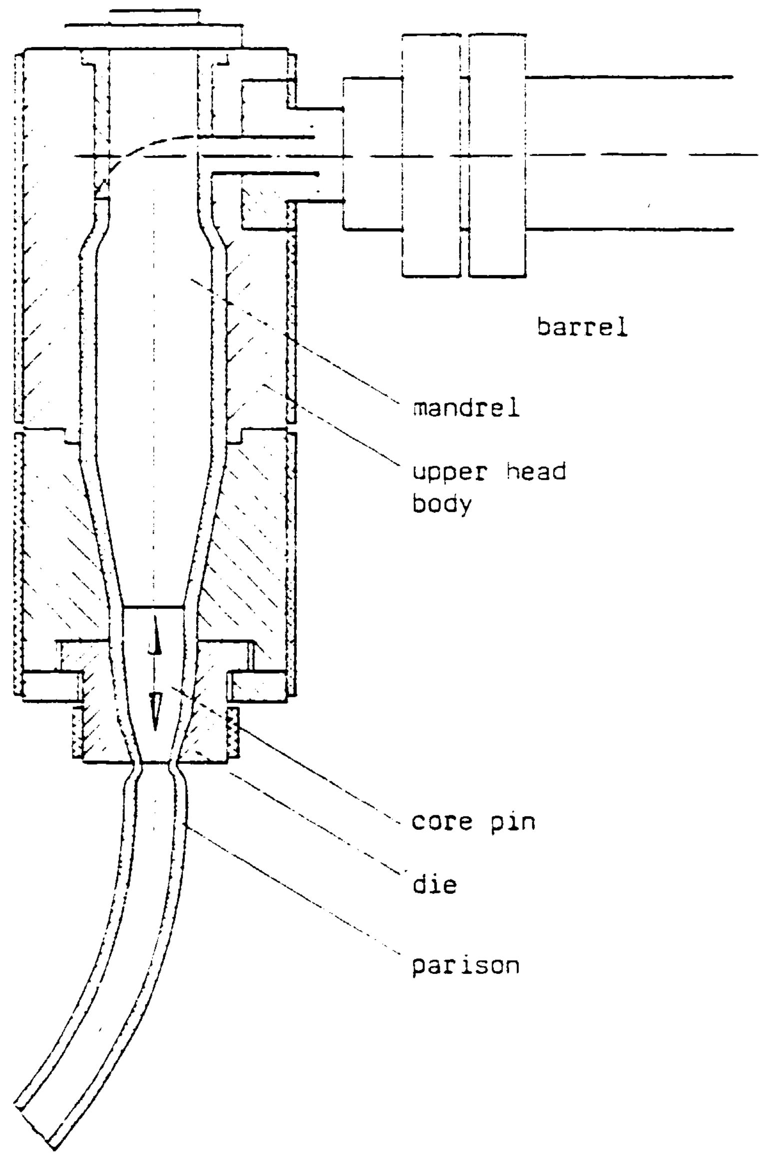


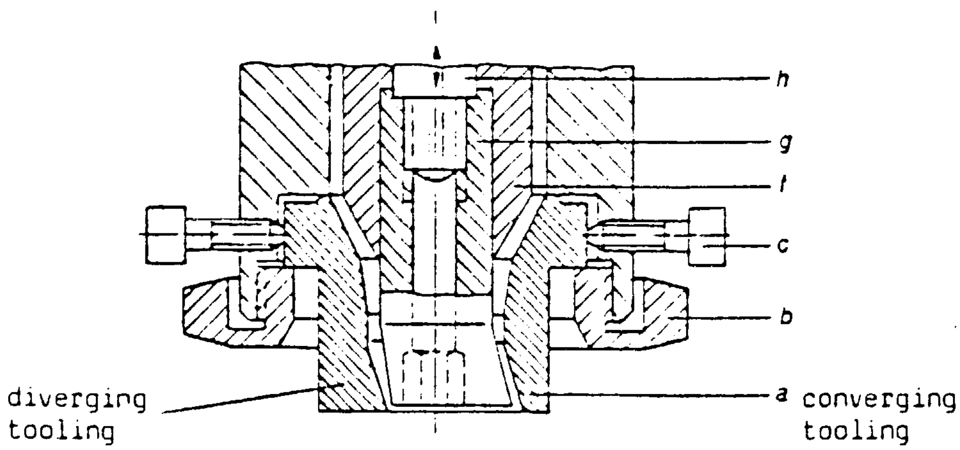
QUADRUPLE HEAD WITH FLOW CONTROL FOR EACH HEAD

Die gap adjustment or the centering of the parison

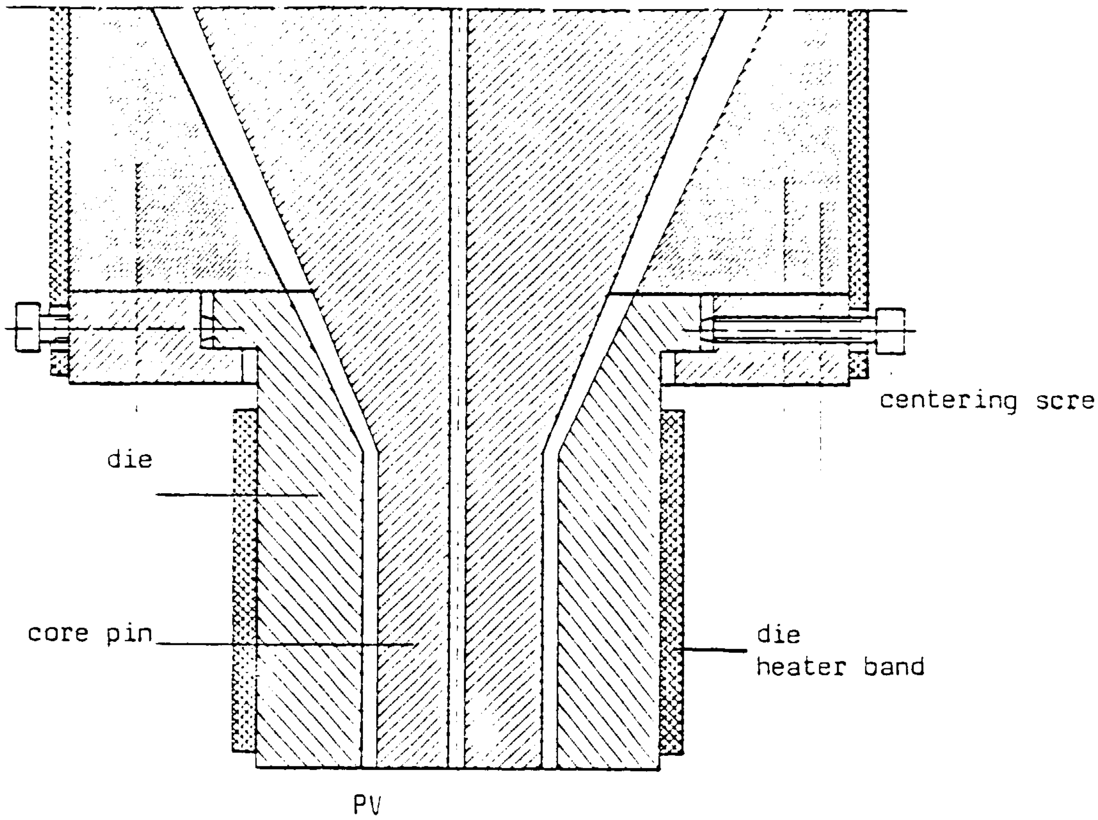
Die gap adjustment is necessary to ensure that the parison leaves the die tooling straight downwards. If the emerging parison curls to any side, this is an indication that the parison wall thickness is uneven. Therefore the produced article does not have an even material distribution. This phenomena can be rectified by centering (moving) the die-ring horizontally against the fixed core pin. For centering the die, 4 or more centring screws are provided in the lower part of the head in such a way, that they can push the die in the appropriate direction. When doing so, it is necessary to loosen the opposite centring screw to allow the die to move.

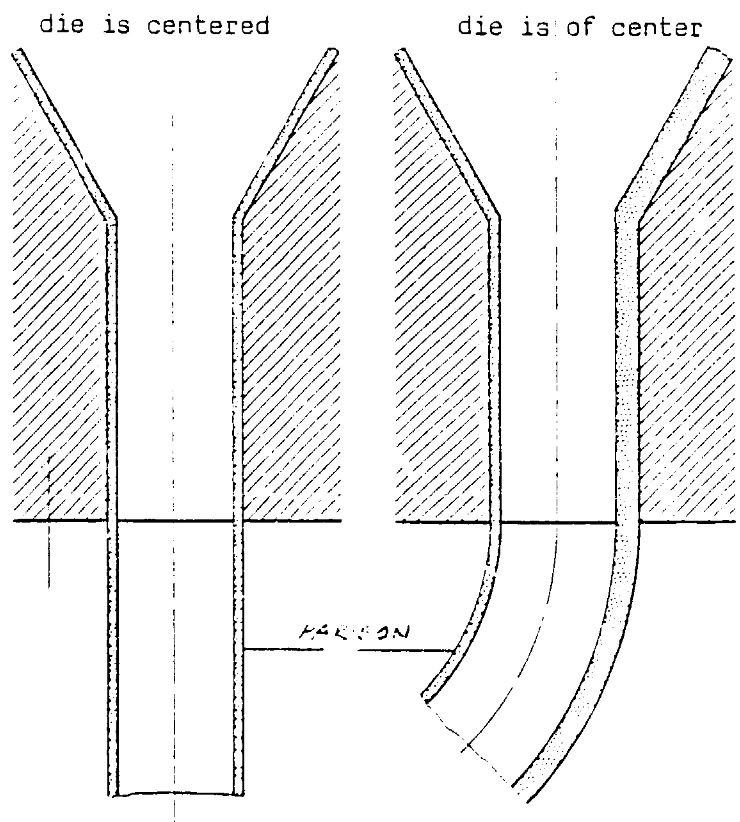
After the centring the parison emerges straight downwards, all centring screws must be tied so that the polymer pressure inside the head cannot remove the die-ring out of its adjusted position. The ring holding the die onto the head must be fastened tight enough to assure that no plastic material leaks through the connecting gap, but loose enough for the die to be centred. Several methods are being developed to achieve just that.





[redacted] Horizontal die adjustment for PE head

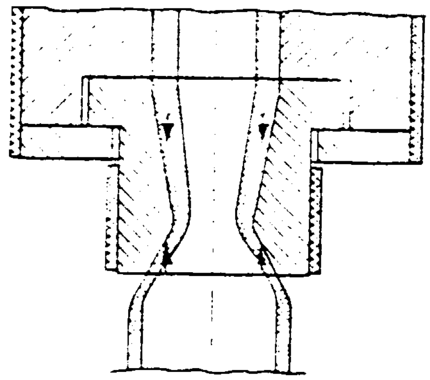




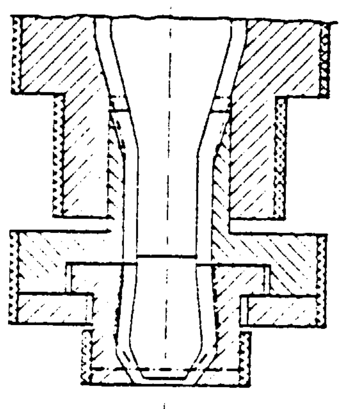
Horizontal die adjustment for PVC head

Parison weight adjustment

The parison weight is adjusted by increasing or decreasing the die-gap. By multiple head production the wall thickness of each parison must be adjusted independently to ensure that all parisons extruded during 1 moulding cycle have the same weight. This is accomplished by mechanical setting screws, whereby the die-gap is altered by either moving the die or the core pin up or downwards.

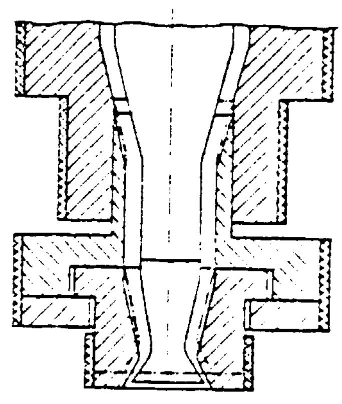


IN THE BASIC POSITION
DIE AND CORE PIN ARE LEVELED



CONVERGING TOOLING

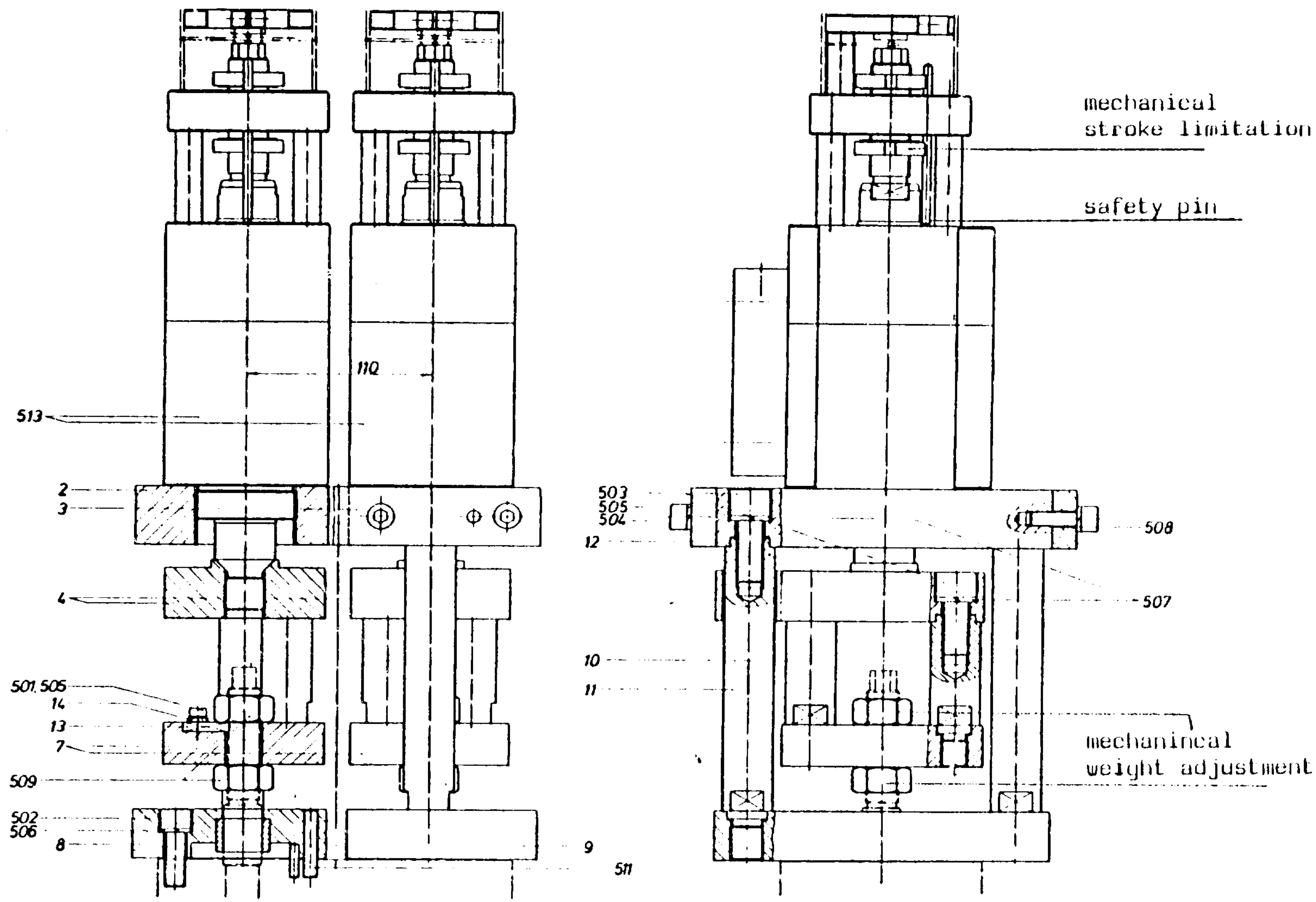
UPWARD MOTION
DIE GAP IS DECREASED



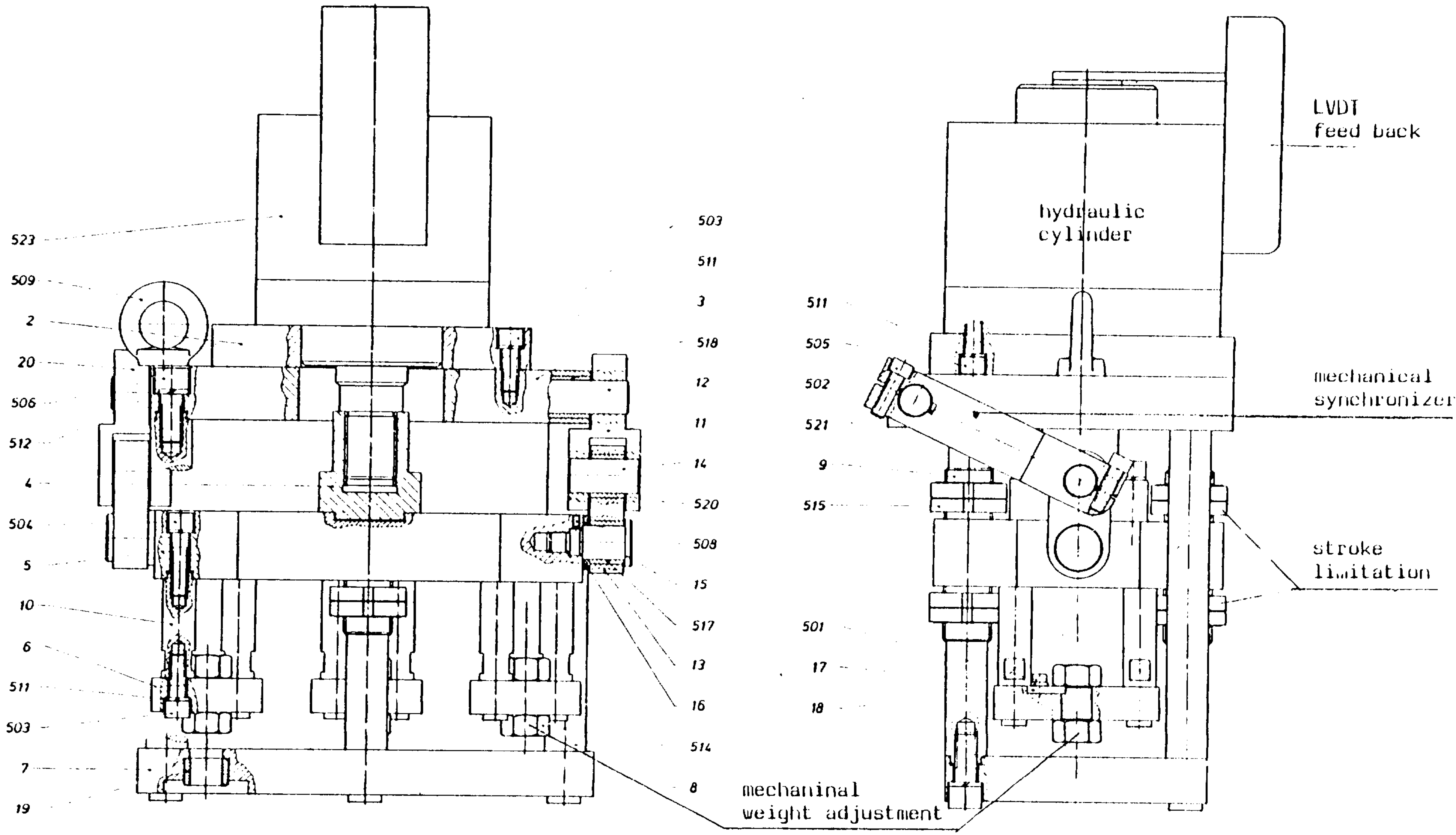
DIVERGING TOOLING

UPWARD MOTION
DIE GAP IS INCREASED

VERTICAL DIE GAP ADJUSTMENT



TWO-PROGRAMMING CYLINDER
FOR TWO CHANNEL HEAD



ONE PROGRAMMING CYLINDER FOR A TRIPLE HEAD

Die - Tooling

The tooling is in general tailored to the article to be produced. The die diameter determints the width of the turbular parison and thus the length of the bootom weld seam.
The core diamter determints the wallthickness and therefore the weight of the product.

Torpedo Head	Mandrel Head	Double Spider Head
Fixed die gap not adjustable Stregt land lengths 15 to 20 max.gap diameter	Adjustable die gap by moving core Land lenghts app. 30° anle	Adjustable die gap by moving the die Land lenghts app. 30°

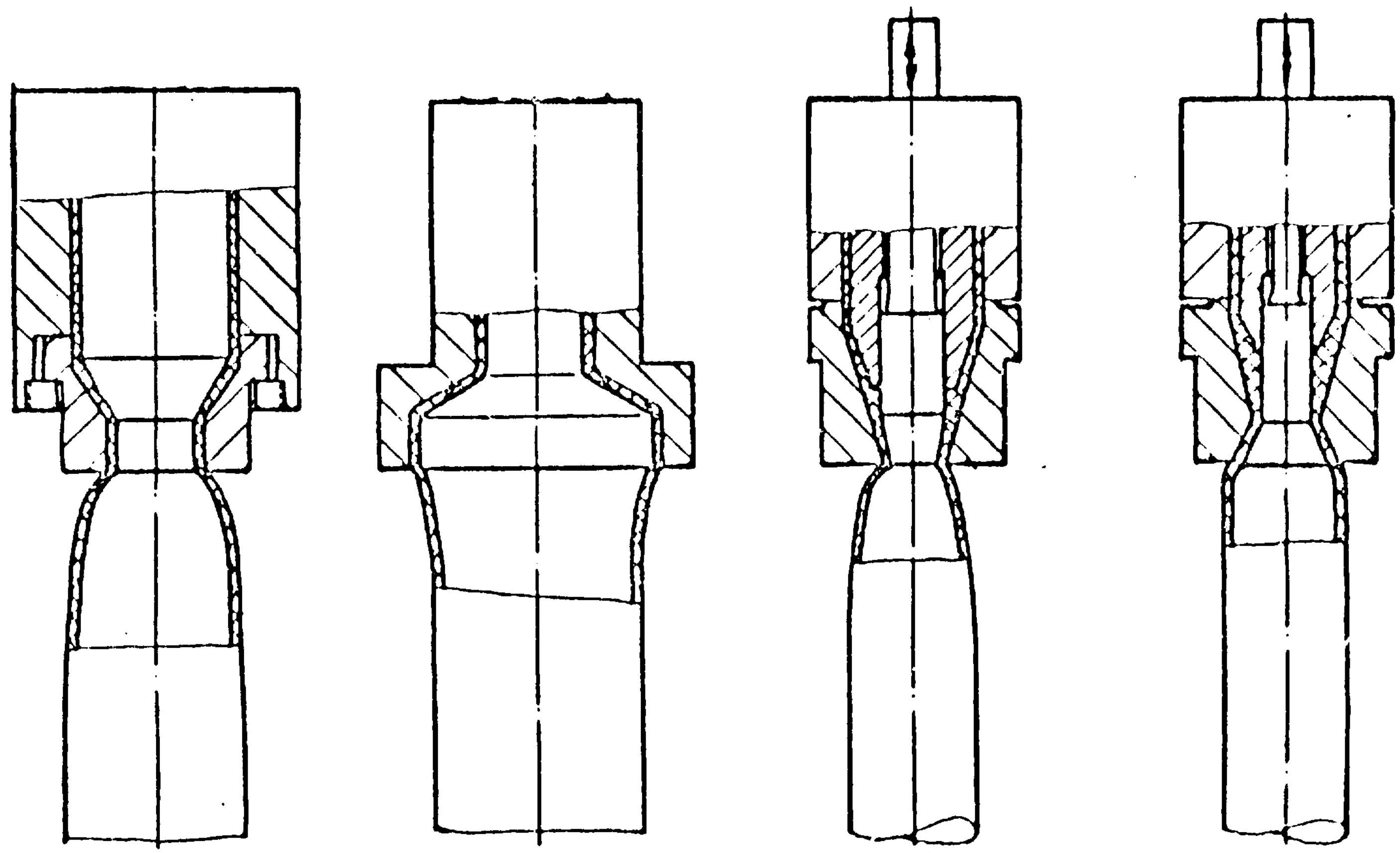
Parison tools

Schlauchwerkzeuge

PARISON SWELL FACTOR

depends upon

- pressure built up
- polymer characteristic



PVC Tooling
parison tries to regain original orientation

Oversized Tooling
negative swell

Converging Tooling
more swell

Diverging Tooling
less swell

Die tooling

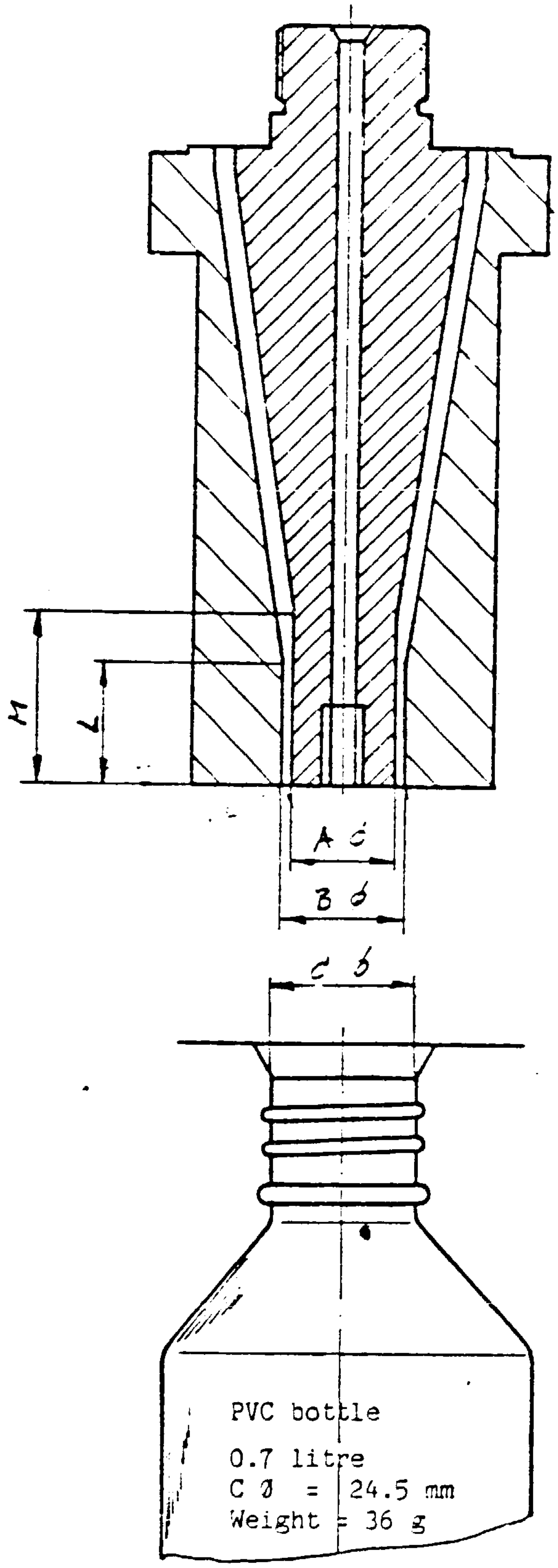
The die tooling is referred to as the lower part of the die head where the parison emerges. It consists of the outer die and the inner core pin, leaving a gap in between where the plasticised polymer leaves the head.

The die tooling is in general taylor-made to the article to be produced. The die diameter is responsible for the parison outside diameter whereas the core pin diame determines the wall thickness of the extruded parison and therefore the arti weight.

Sin the round extruded parison is pinched and welded together by the closing mo , the parison outside diameter automatically results in a given length of the welding seam in the article bottom.

For symmetrical round articles such as bottles or round containers the emerging parison has a symmetrical cross-section with equal wall thickness. The blow air evenly expands the parison onto the mould and the articles have an even wall thickness. Square or oval containers are produced with an assymetrical or ovalized tooling to assure an even material distribution around the not concentrical container shape.

PARISON TOOLING DESIGN FOR S1/60 PVC



The following facts have been found out by experience:

(a) Die diameter B of 18.7mm results in a parison diameter suitable for a ne[ck] opening C_1 of 23mm.

(b) A ring area of 85.9mm² results in a bottle weight of approx. 40 g.

I. Calculation of the required die diameter B for a given neck diameter of 24.5mm diameter.

23mm neck requires double point Die 18.7mm
24.5mm neck requires Die X mm

Formula: $X = \frac{18.7 \times 24.5}{23}$ = 19.9mm new Die diameter

II. Calculation of the new Core diameter

(a) 40g results from a ring area of 85.9mm²

36g results from X mm² Ring area

Formula: $X = \frac{85.9 \times 36}{40}$ = 77.3mm² for 36g.

(b) Die diameter 19.9 results in a Ring area of 311 mm²

Subtracting the ring area of the new core of 77.3 mm²

= 233.7 mm²

233.7 mm² results in $\frac{233.7}{0.785}$ = 2975

= 17.2 mm new die diameter

III. Determining Dimension L

Die diameter 19.9
Core diameter 17.2

2.7 ÷ 2 = 1.35 mm Gap

For a Single Head 20 x X
For Double Head 15 x X

L = 20 x 1.35 = 27mm long

M = L + 8mm = 27 + 8 = 35mm long

EXTRUSION TOOLING LAY OUT
For PVC

Tooling ovalization or profiling

For round articles, the uniform parison expands an equal distance until the mould wall is reached.

For oval or square containers, the extruded round parison reaches the mould wall sooner at the shorter expansion distance (minor axis) and expands further where the expansion distance is larger (major axis).

The parison will cool and solidify as soon as the parison touches the cooled mould surface. The larger expansion distance results in a thinner article wall.

To compensate these logical phenomena, the extruded parison is shaped by the profiled tooling in such a way that the parison is made thicker where the expansion is further and thinner where the parison is only expanded a little.

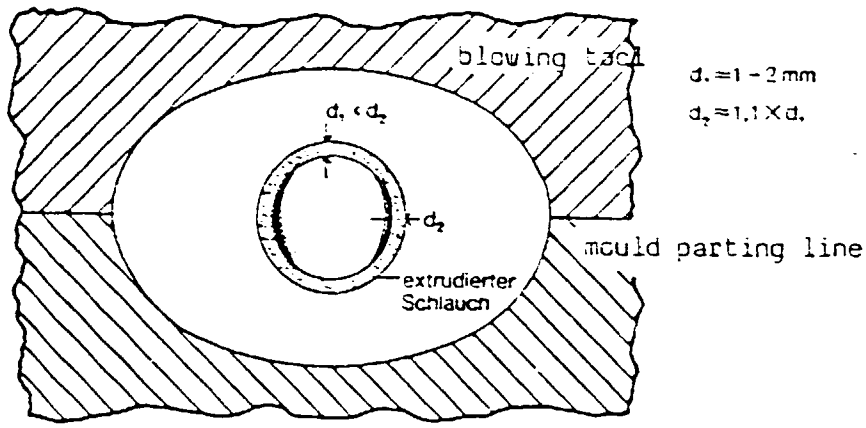
This profiling can be done at the die or at the core pin, the result is nearly the same. The important part is that the profiling is repeatable as for multi-parisons, for instance. It is advisable to machine the tooling off-center on a lathe or a milling machine.

The final result is achieved by trial and error.

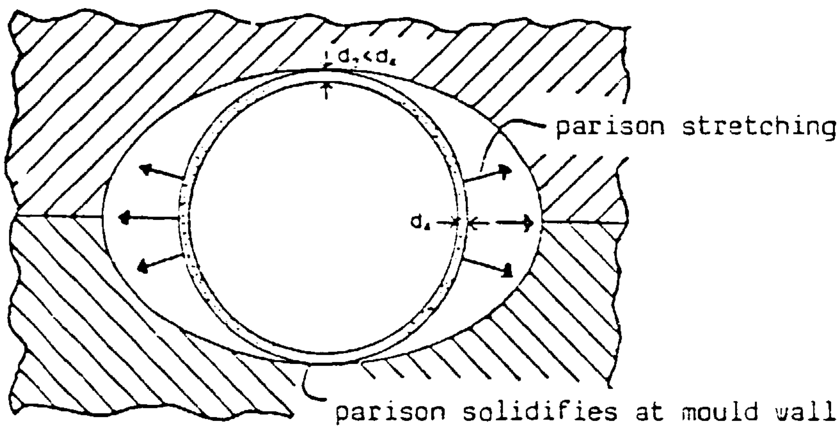
One should always start to ovalize or profile the tooling by 0.1 or 0.2 millimeters at the time depending on the tooling diameter. As a guideline, a few facts:

The blow-up ratio (max article diameter divided by parison diameter) for round containers should not exceed 4 : 1. For oval bottles appr. 5 : 1, for handle containers appr. 3 : 1. If the major axis does not exceed 1.25 of the minor axis ovalization is not required.

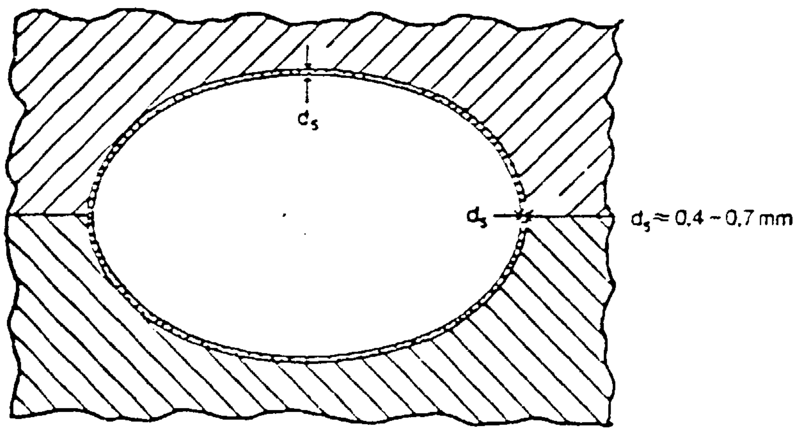
1. At blowing start



2. During the blowing phase



3. End of the blowing cycle



BLOWING OVAL CONTAINERS

Parison programming

Programming the parison means changing the die-gap opening more or less during the moulding cycle. Thereby, providing thick or thin sections on the extruded or ejected parison length required for one moulding. If a straight non-programmed parison is formed into an article, the bottom and shoulder rim, where the parison is stretched further will result in a thin wall area.

By programming the parison length in such a way that the extruded parison has a thick wall area where the parison is stretched more, then the blown article will have more even wall thickness distribution and will be stronger in the bottom and shoulder rim area.

By employing parison programming, the material distribution is improved and the overall weight of the container can be reduced by approximately 10 up to 15 %, this is a considerable cost reduction without sacrificing the container strength. If the not required thick areas on a container are limited, the cycle time can also be reduced, due to shorter cooling time, depending on the material type and the container shape. A saving up to 20 % can be accounted for.

Changing the diegap can be carried out by moving the die or the core pin up and down, depending the head construction principle. Center-fed heads usually program the outer die ring up- and downwards.

Two differnt programming principles are on the market today. One is a timer base programmer, the other is a more sophisticated electronic programmer with close-loop control.

The mechanics involved are relatively simple. An air or hydraulic cylinder acts via a lever or direct to move the dietooling up or down. The moving die is increasing or decreasing the die gap to create thick or thin parison wall sections.

Timer base programmer

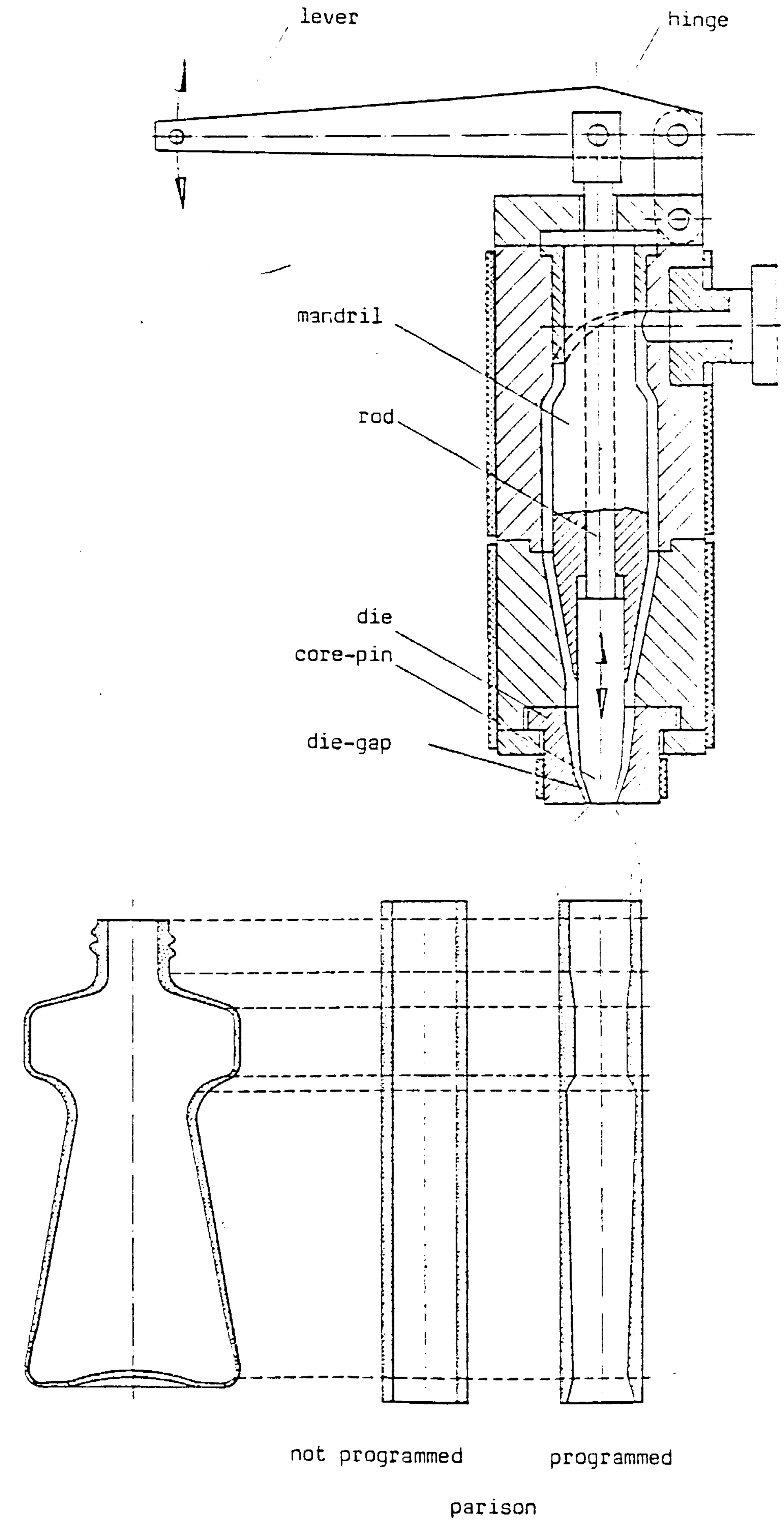
By using a timer base parison programmer, generally three adjustments are required: time - stoke - speed.

Time: The time setting determines when the operating valve changes the programming position from up to down or vice versa.

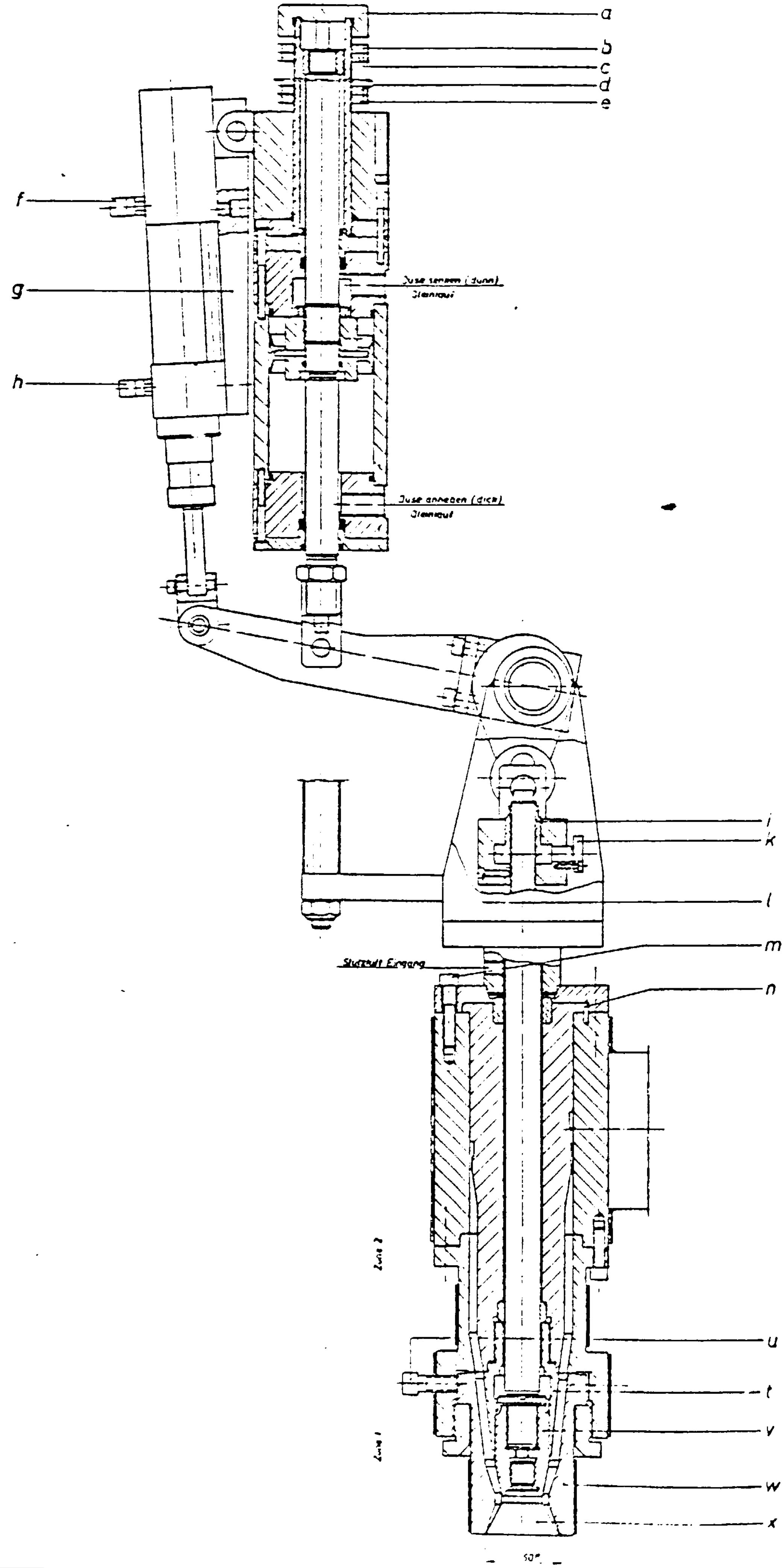
Stroke: The programming cylinder piston stroke setting determines how much the die is allowed to open or close to create the thick and thin sections in the parison.

Speed: The speed control of the operating piston determines how fast the piston travels from one cylinder side to the other. If the piston travel is very slow, the change-over from thick to thin, for instance, will be gradually, but if the piston travel is too fast, the change-over occurs suddenly and leaves noticeable ring-markings on the container.

The use of this relatively inexpensive system is limited, because the number of timers employed (2 up to 4) restricts the number of possible wallthickness alterations. Due to the mechanical stroke limitation, the thick and thin areas have always the same preset wallthickness. The travelling speed is preset for a given down- or upstroke, therefore the changing from thick to thin and vice versa is always the same.
If a more sophisticated programming is required, an electronic parison programmer must be employed.



Timer-controlled parison programming



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Electronic parison programming

For electronic parison programming, the mechanical set-up on the diehead is almost the same as for timer-based programming.

The programming system is a closed loop control system and consists of the following components:

Programming unit - servo valve - and feed back device.

The feed back device can be a potentiometer or LVDT (Linear Voltage Deviation Transdusor) it sends an electrical signal to the programming unit to give the exact physical position of the programming piston and consequently the width of the die gap.

The servo-valve controls the motion (stroke and speed) of the programming piston.

The servo-valve unlike normal direction of valves reacts very sensitive to an electrical DC signal send out by the programming unit to hold or move the programmin piston into any given position depending upon the signal level being sent to the servo-valve.

The programming unit houses the servo amplifier to control the servo-valve.

Two separate signals are fed into the amplifier. The input signal from the programming unit is positive and the feed back signal from the programming piston is negative, so the difference between these two signals is zero. The programming pisto will remain in a position resulting from these singles. The input signal consists of two signals coming from two different sources, the weight control potentiometer and the patch pannel.

The weight control potentiometer can be adjusted between zero and 100% thereby movin moving the die gap from totaly close to half of the maximum piston stroke.

The patch pannel can have inserted pins, sliding switches or sliding potentiometers the all do the same, deliver the second singal required to move the die gap and therefore the programming system from the piston position set by the weight control (50% of the total stroke) to the maximum piston stroke i.e. the die gap is now all the way open.

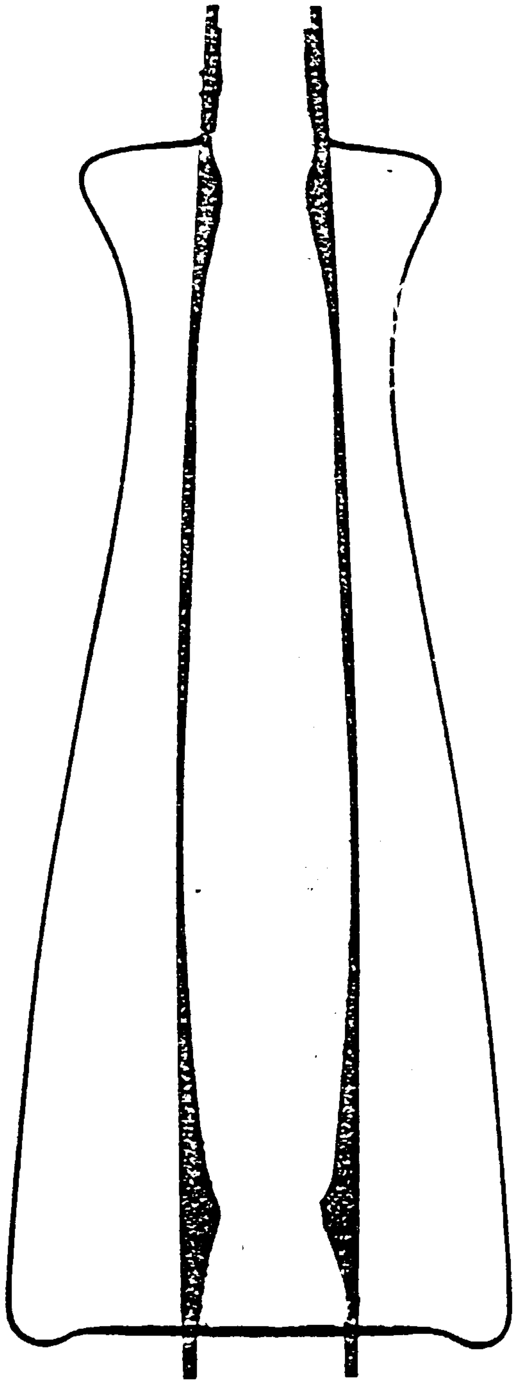
In other words the weight control determines the basic parison wall and the patch pannel adds a profile onto it.

Patch pannels come in different executions and programming ranges starting from 10 programming points upto 64 programming points. The parison length required for one molding including top and bottom flash is devided by the number of available programming points. i.e. for a given product, with a 10-point programmer the distance between 2 programming points is larger as by using a programmer with f.e. 32 points, here the distance between 2 programming points is shorter.

More programming points allow closer and finer programming. The parison length required for one molding cycle it is directly related to a given time span f.e. : a bottle hights of 320 mm requires a parison including top and bottom flash of approx. 350 mm. Is the bottle weight roughly 45 g the cycle time required is approx. 12 sec. i.e. in 12 sec. a parison length of 350 mm emerges from the die. Is a programmer employed has only 10 points the distance between 2 programming points is 350 devided by 10 = 35 mm, by employing a 64 point programmer the distance between 2 programming points is reduced to 350 diveded by 64 = 5.46 mm.

Every programming point represents a potentiometer setting the take off point (programming point) can be set anywhere in between 0 and 100% of its value.

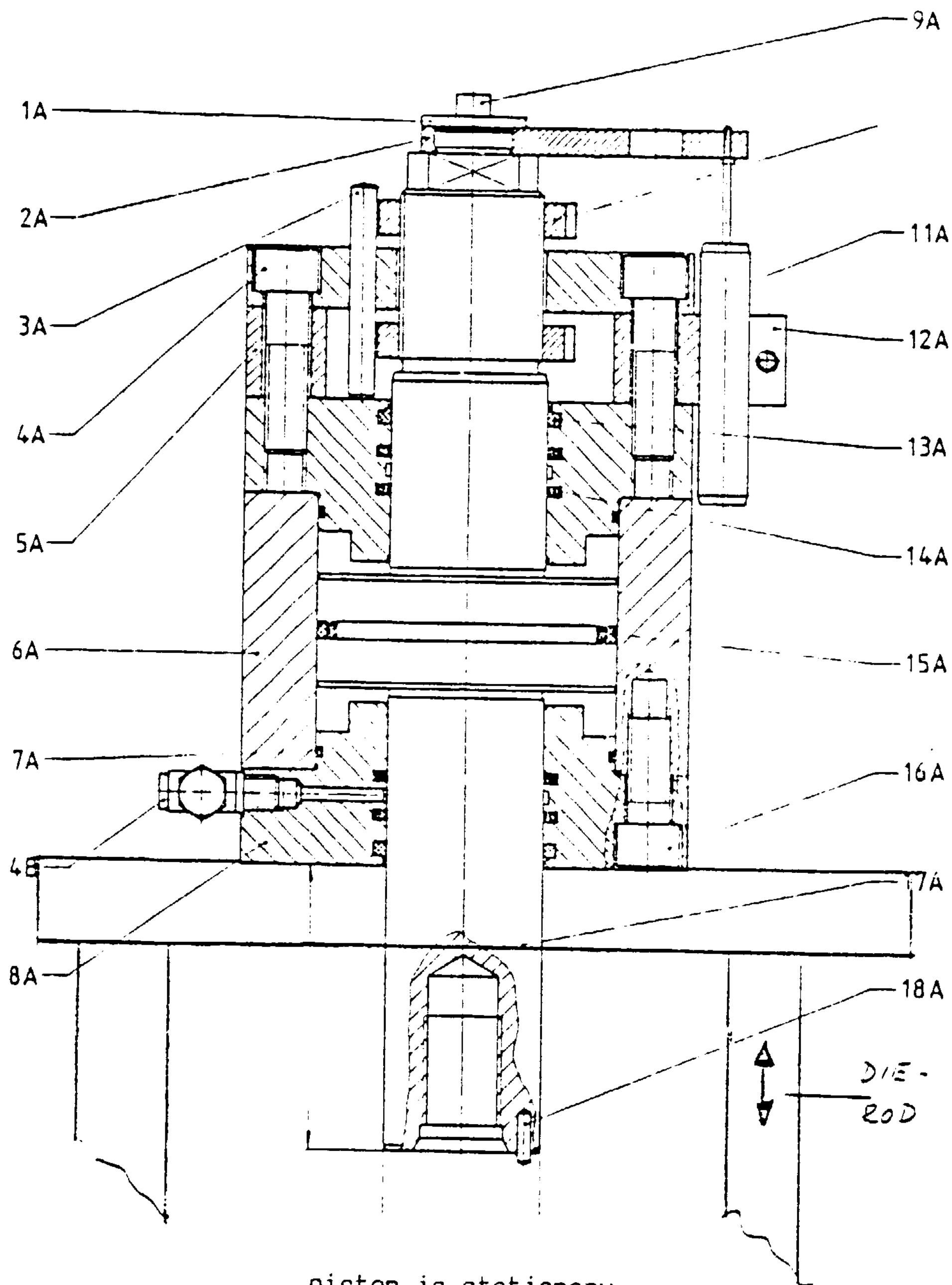
A time circuit built into a programming unit measures the cycle time and devides this time span into equal time intervalls or signal. f.e. by using a 32 point programmer the 12 second cycle is devided by 32 available programming points (32 devided by 12 = 0.375 sec.) i.e. every 0.375 sec. the programmer advances from 1 point (potentiometer setting) to the next one and adds the set value of the following programming point to the adjusted basic wall-thickness setting. The servo-valve receives the alterd value and moves the programmer piston into a position equivalent to the signal. The feed back signal reports that a motion has been executed. This way in a adjustable profile on a patch pannel by pins or potentiometers is transformed onto the emerging parison.



- **Weight Savings:** The elimination of material on the finished product in previously thick sections and particularly in the pinch-off areas where it is not utilized can lower the cost of a container due to savings on raw material
- **Production Increase:** Due to elimination of thick spots in a container, the cooling time can be shortened since the mould cooling capacity is utilized more efficiently througnout the container walls
- **Quality Improvements:** Material distribution can be controlled in the critical areas of the container to reinforce its performance or to keep a container flexible as required

Cost Reduction: The container performance will be maintained consistently to produce a greater net output meeting specifications at minimum allowable weights in production. The setup time will be considerably reduced due to the systematic control means of the programmer

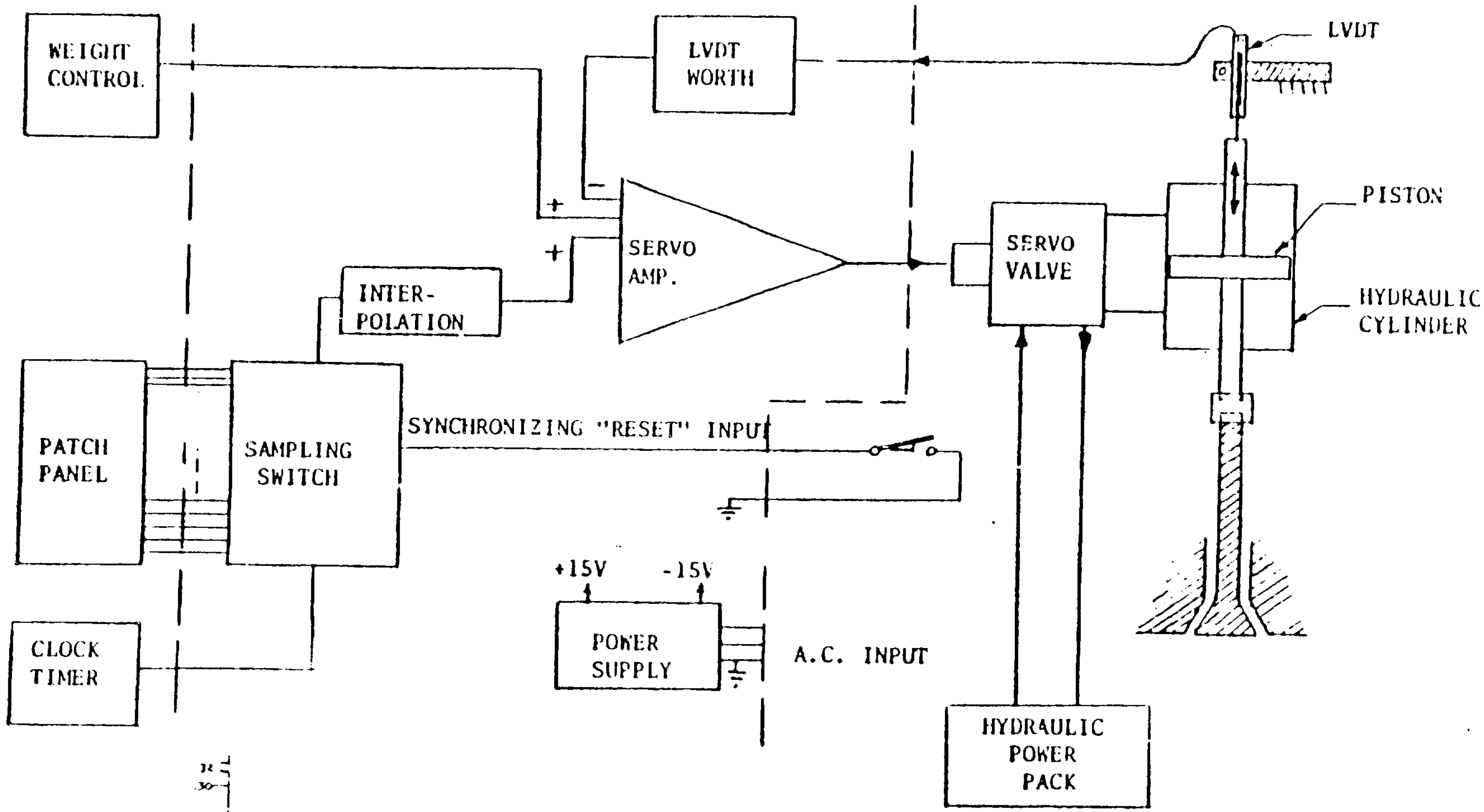
PARISON-PROGRAMMING CYLINDER

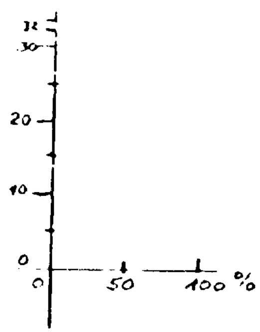


piston is stationary
housing is moving

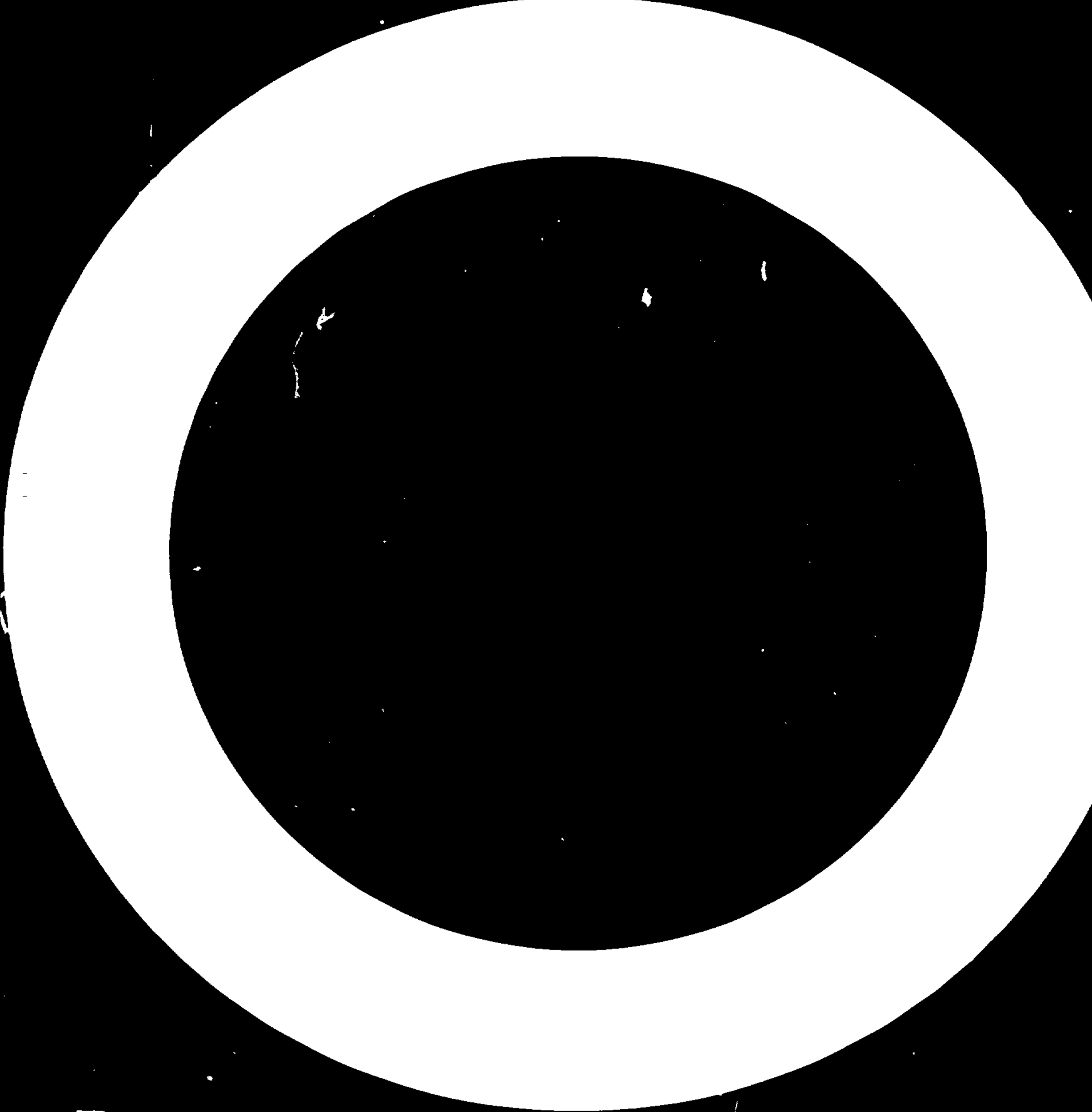
PROGRAMMING CYLINDER

BLOCK DIAGRAM PARISON PROGRAMMING





PARISON PROGRAMMER
FUNCTIONAL BLOCK DIAGRAM



Parison cutter

Accumulator heads do not require parsion cutting devices. Here the parison is separatged by the closing die tooling at the end of the parison ejection.

By continous extruding blow moulding machines the parison length required for a moulding cycle must be separated to allow for the parison transfer.

Different material type and parison diameters require a different parison cutting device.

It must be pointed out that the parison cutting in conjunction with the pre-blow air setting is a very vital moment. If the setting is not correct the molding machine will not produce a good article.

In general 4 different cutting devices are being used:
Stab cutting knife - impact swing knife - hot wire cutter and parison shears.

Stab cutting knife are used to separate PVC low and high density PE upto approx. 55 mm diameters for single and multi parisons.

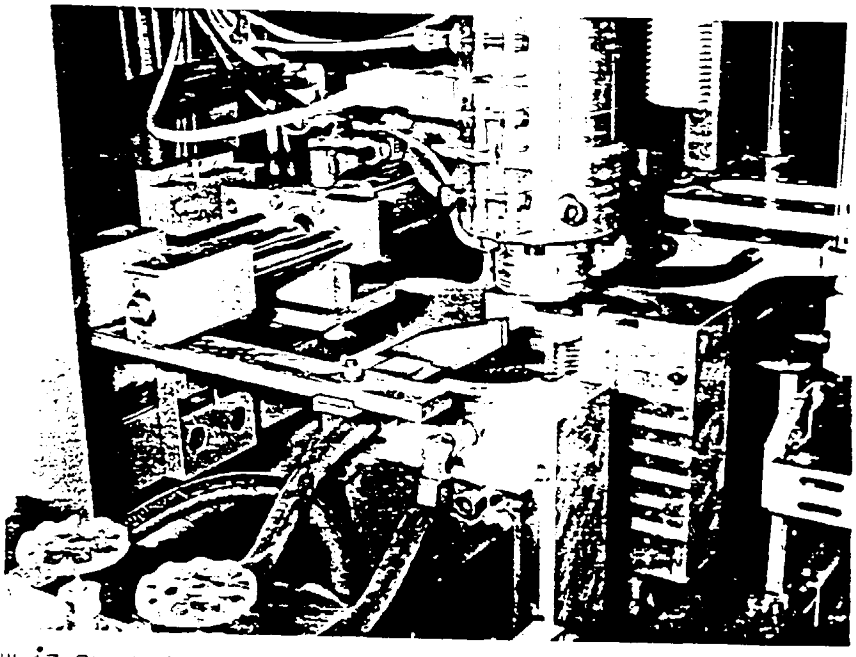
PP, PC, PS cannot be cut with this knife type. This polymer will not separate clearly it will pull strings.

The set up consists of an air cylinder actuating the knife blate on two guiding roods for- and backwards during one moulding cycle. The knife blate made from 1.5 mm knife steel has a 60 degrees tip, which enters the parison and separates it by moving forward. The immediate backwards stroke allows the following parison to run freely. The cutting blate should be set approx. 10 to 15 mm below the die tooling. The timers setting for the back stroke should be set long enough to allow the cutting piston to travel its full stroke.

Stab Knife

The Stab knife is employed for the cold cutting of parisons up to approx. 55 mm. diameter. Stab knives can be supplied as single or multiple units.

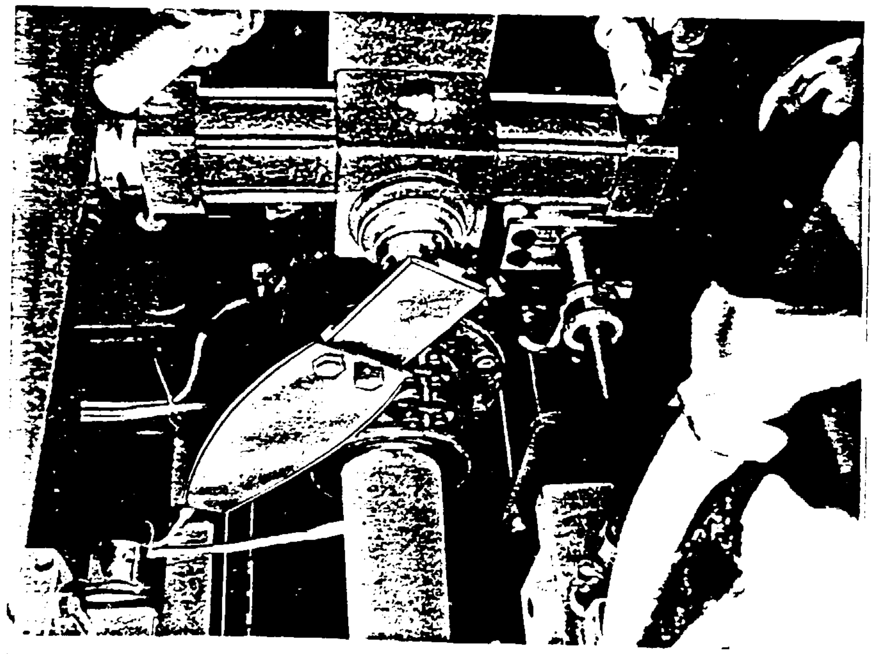
However, there are reservations concerning certain materials like PC and PP, for which this process is unsuitable.



Ill. 17: Stab knife

Impact Knife.

The impact knife is preferably employed for the cold cutting of PVC at the larger parison diameters of approx. 55 mm. and can be supplied in single or double version. The impact knife can also be used when processing HDPE and LDPE.



Ill. 18: Impact knife

Inpact-swing knife

This cutting system is meanly used to separate PVC parisons of diameters larger than 55 mm diameter. It can also be used for low and high density PE. It operates with a pneumatic rack cylinder which turns a pinion-gear at a approx. 180 degrees for- and backwards. To assure a good cut the knife must swing at a high speed, but to extend the life time of the equipment the end cushion of the piston must be slow. Since the sharp cutting blate moves very fast it can present a hazard. Therefore in additional safety lock is implemented in the receiving shaft to prevent the knife plate from falling out if it should become loose. The knife swings in one direction doing one cycle and backwards in the next cycle.

Hot wire cutter

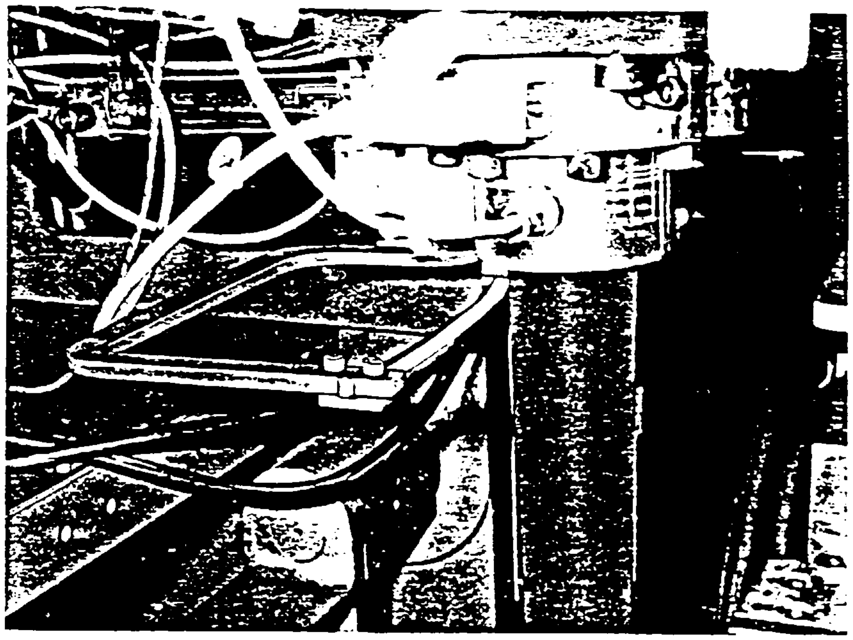
This cutter can cut all mouldable polymers.
However if PVC is cut with this system it will burn the material during cutting. By mixing the regrind back into the system burned material particles will be seen in the product.

The cutting system consists of two isolated arms to hold the cutting blade or cutting wire. Each arm is connectd to the secondary winding of an adjustable isolating transformer. A voltage between 0 and 6 volts will drive a current up to 90 amp through the cutting wire and heats it up, hot enough to melt through the parison. To extend the life time of the cutting wire the temperature (current) should be kept low.

A current supervising circuit will stop the blow moulding machine if the cutting wire is interupted. An air cylinder moves the hot wire cutter in one cycle forward and in the following moulding cycle backwards.

Hot Wire Cutter.

The hot wire cutter or melting cutter separates the preform with an electrically heated filament strip. It is employed for special materials, e.g. PP and PC as well as for extremely large thin walled parison diameters. The hot wire cutter can also be combined with a welding device.



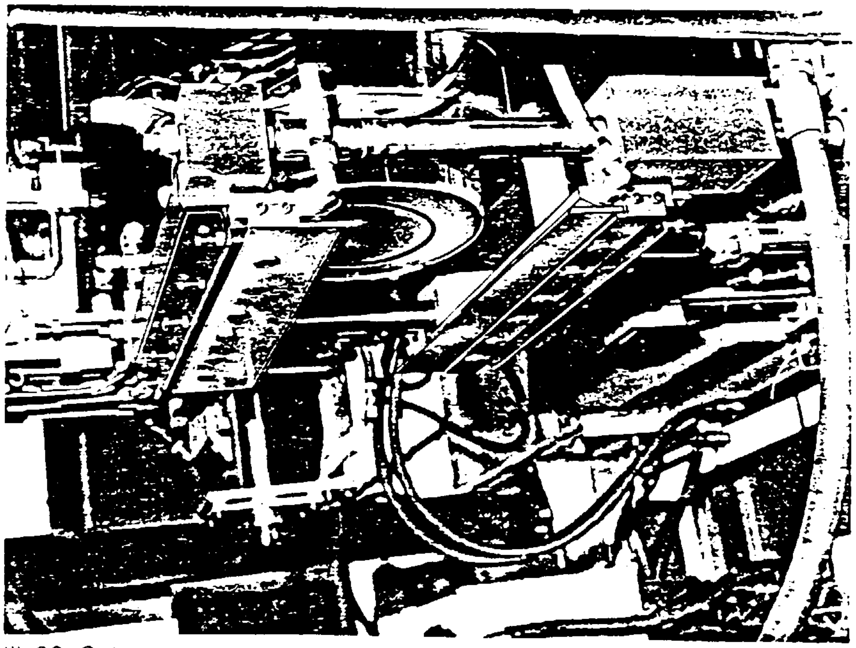
Ill. 19: Hot wire cutter

Cold Parison Shears

The cold parison shears represent the universal parison cutters for medium and large parison diameters. They are employed for all materials.

The cold parison shears can be combined with a welding device which simultaneously with the separation of the parison also seals the lower part of the preform. This enables a small pressure rise to build up in the parison, reliably preventing the parison from collapsing and sticking together.

The employment range for the cold parison shears lies particularly in the production of mouldings with handles, containers, and flat technical articles.



Ill. 20: Cold parison shears.

Parison shears(scissor)

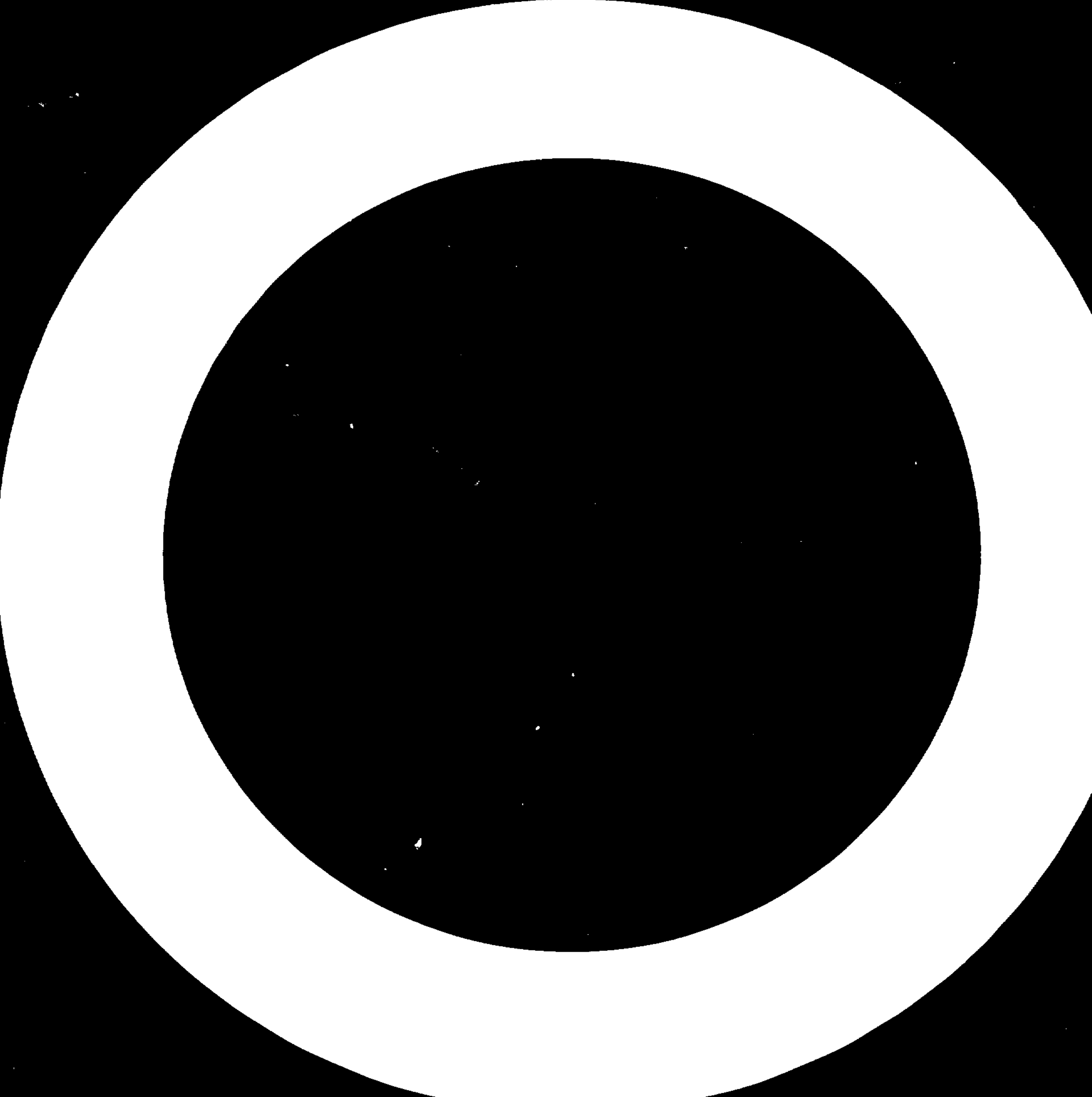
This cutting system is a universal cutter for open or sealed parisons, for single or multiple head production, ranging from very small to very large parsion diameters it cuts all moldable polymers except PP.PC. and PS. The cutting blates acts as a scissor and shears the parison a part.

The feature of this cutting system is that it can be combined with welding base to seal the parison above the cut. This is very important for the production of handle ware, thin walled and technical articles as well as for needle blow.

A sealed parison can be inflated with pre-blow air to accomplish the following, support the parison to make it stable, enlarge its diameter to compensate for too small die tooling and prevent the parison from collapsing.

Adjusting screws allow the setting of different cutting blate tensions and welding bar distance for different parison wall thicknesses.

The cutting system is operated by an air cylinder with a rack and pinion drive for a simultaneous cutting motion of the two blates. The operating mode is adjusted by two timers. One timer initiating the closing the otherone gives the signal to open the shears and welding bars.



Mould clamping units

The clamp unit is a mecanisme to close or open two mould (mounting) plattens in order to receive the extruded or ejected parison between two mould halves.

The opening and closing motion can be actuated by pneumatic or hydraulic cylinder either direct or via toggle system. The platten motion is synchronized by a mecanical system to assure that both mould caring plattens closed parallel in the clamp unit center.

Most clamping units are equipped with a variable mould closing opening speed to assure 3 closing and opening faces.

Face 1.:
The mould closes at fast closing speed to save valuable cycle time.

Face 2:
The mould closing speed is reduced as soon as the mould brings the parison together to be welded. If the closing speed in that face is too fast, the welding is very poor, because the polymer did not have the time to reknit and the mould cutting edge angle allows the polymer to flead to the outside. It would produce a good flash separation but a poor welding line. The slower closing speed during the welding face produces a better welding seem but it also consumes more cycle time. In production an inbetween must be found to have a good weld line and still be ecconomical on cycle time. The weld line quality depends also on the execution of the mould cutting edge while the mould closes slow, during the welding face the polymer has time to recombine. The cutting edge angle on the mould pushes the material upwards and supports a good welding. However during the welding face the outside polymer layer in contact with the mould has cooled off to a certain degree. The article has a good well seem but the cutting for flash separation poor

In face 2

The mould closing speed is accelerated again at this time, the welding is already finished and the high final closing speed separates the flash layer so far, that it can be torn off manually or be separated by the post operation unit. Apart from the clamping speed a clamp unit must be equipped with sufficient clamping force. The clamping force is required in two situations.

The first, situation is during face 2 and 3 where a long weld line must be recombined f.e. by producing technical blow moulding and patrol tanks where the parison is pinched and welded around the total article conture. A clamping force between 80 kg upto 250 kg for each centimeter of the welding line is necessary depending upon the processed polymer and the mould size. The second situation is during the blowing face, where the blow pressure between 5 and 10 bars act at a relative large mould surface area.
Mould area multiplied by the blow pressure results in a force, working against the mould closing force. So the mould clamping force must always be higher as the force acting from the inside.

During the mould opening face the platten moves also at differet travelling speeds.
Containers with undercuts in the mould conture require a slow pre-opening of the mould to allow those undercuts to become free.
If the mould opens fast from the beginning, the container can tilt inside the mould and the production cycle must be interrupted.

As soon as the undercut areas are cleared the mould platten speed will increase to save cycle time again.
Towards the end of the opening stroke the travelling speed is reduced to allow a smoothe endcushioning of the platton stroke. As mentioned before the different travelling speeds can be created by different means. Small machine models employ a toggle system whereby the toggle is driven by an electric brake motor. The toggle system naturally creates a slow fast slow motion. For larger machines above 5 l a combination of toggle and hydraulic cylinder is employed. Whereby the brake motor creates the fast motion and the hydraulic cylinder creates the slow

motion with high clamping force. Other machine models employ a toggle system only driven by an air or hydraulic cylinder. Toggle systems have positive and negative aspects. The positive aspect is that a small cylinder create a strong clamping force keeping the installed power supply to a minimum.

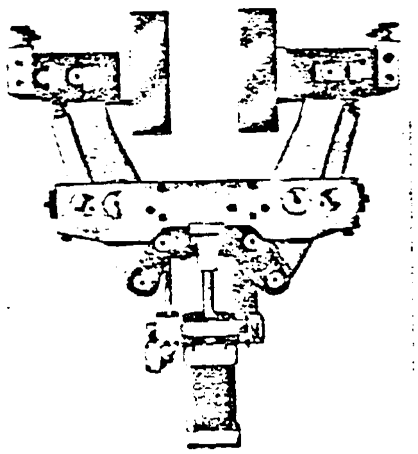
but it is also necessary that the moulds in between the platen have a specified mould shut height.

If the mould shut height of the 2 halves is smaller than specified, the mould clamp unit will not develop any clamping pressure on the mould, but if they are larger than specified, an excessive amount of pressure can be developed, harming the equipment.

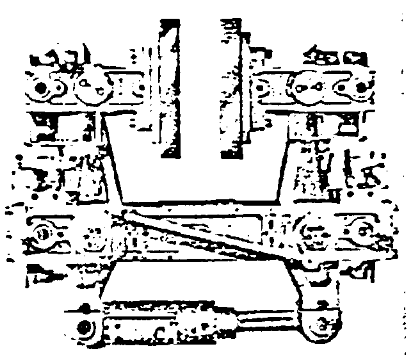
Several methods to prevent the build-up of excessive clamping pressure have been developed. One is to provide a pressure relief valve to restrict the operating pressure at the closing cylinder, another is to build a flexible link such as a elastic spring package into the toggle system. Machines without toggle clamp either have 2 clamping cylinders on each mould platen or a centrally located clamping cylinder in order to operate both clamping platens simultaneously. This solely depends on the overall machine concept and the application.

Some clamp units have either 2 or 4 tie bars, other ones have none at all. Clamp units with tie bars can be built relatively light and still have a strong clamping force, but the application of such units is limited.

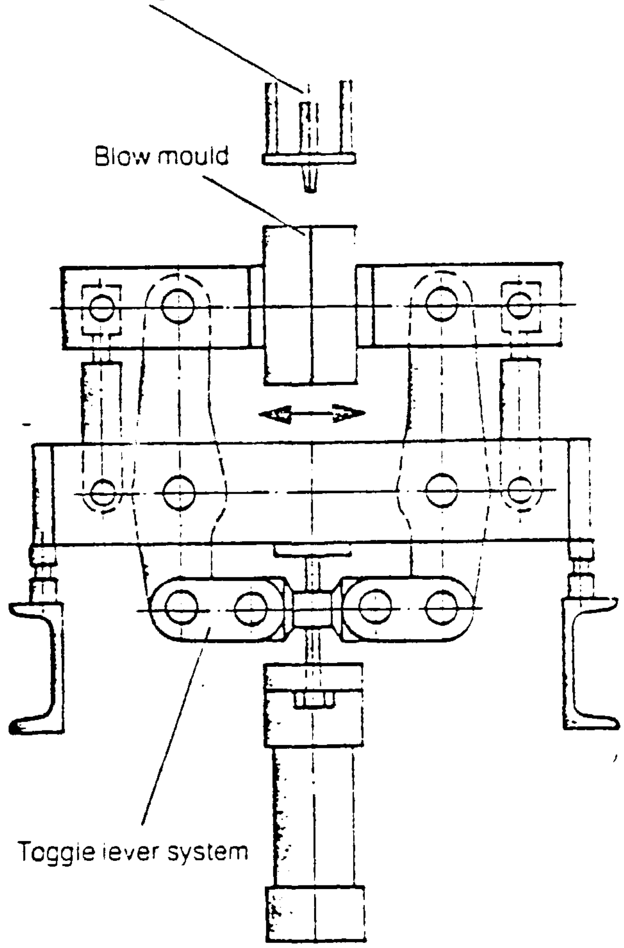
Modern machines require that the articles are delivered automatically and completely finished. If the clamp unit is equipped with tie bars, automatic article transfer out of the machine or into the postoperation stations is not possible. The blow moulding machines offered today by the manufacturers are mostly without tie bars, ranging from a few ml contents up to 750 l.



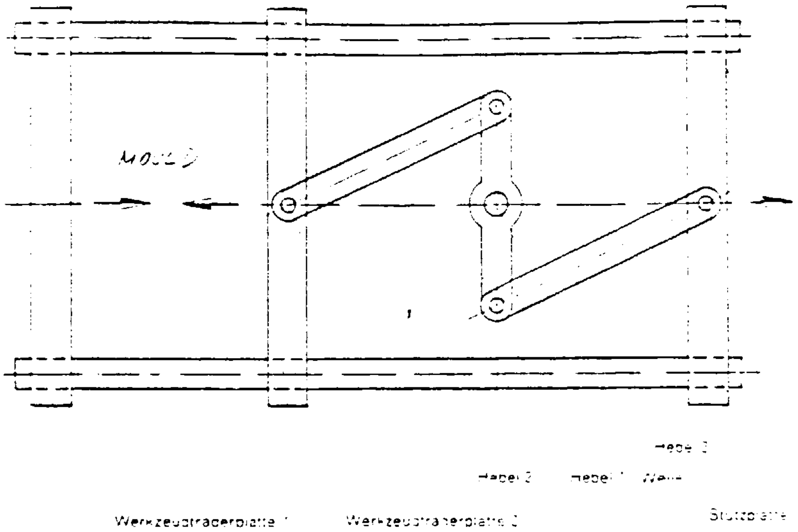
Ill. 1: Closing function with toggle lock system

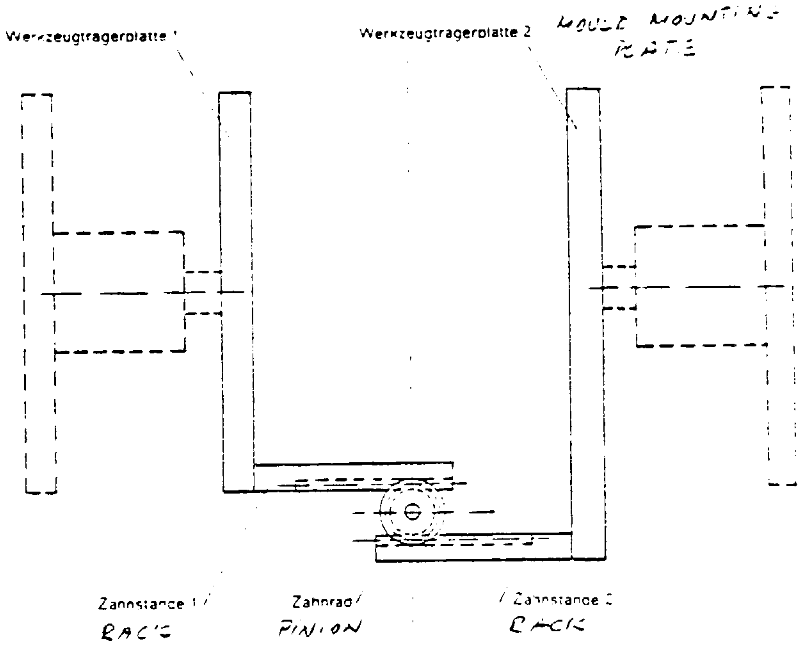


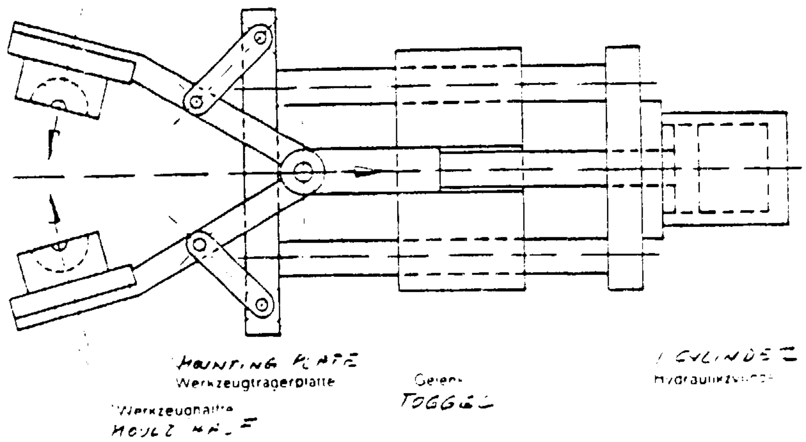
Ill. 2: Closing function with hydraulic cylinder



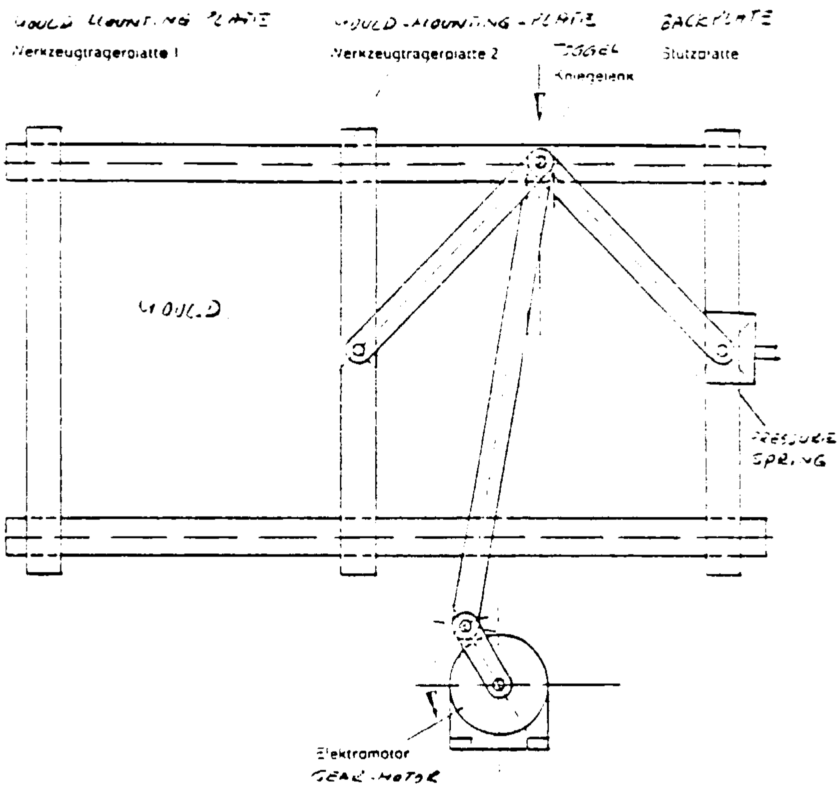
Clamp units without tiebars with taggle and direct operated by an hydraulic cylinder

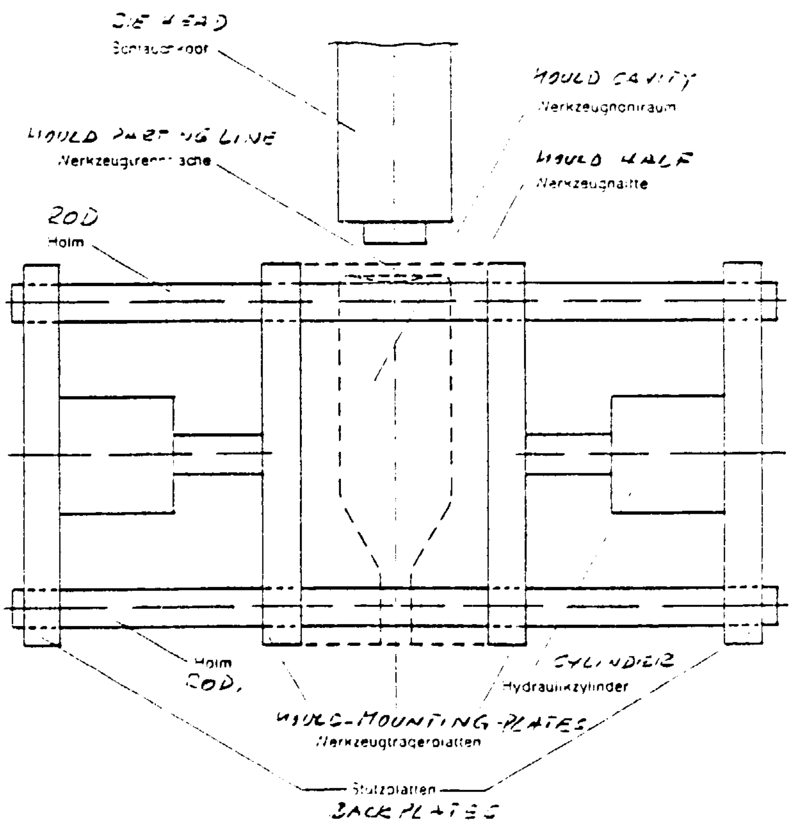






Different clamp unit systems
with and without tiebars





Clamp units with tiebars
mechanically and hydraulically operated

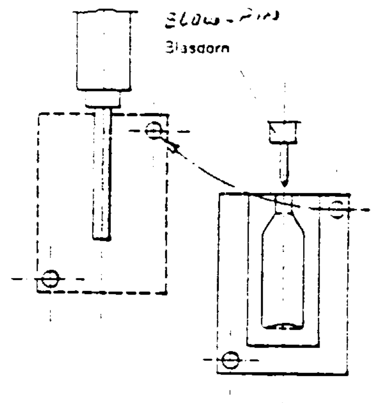
Clamp unit transport

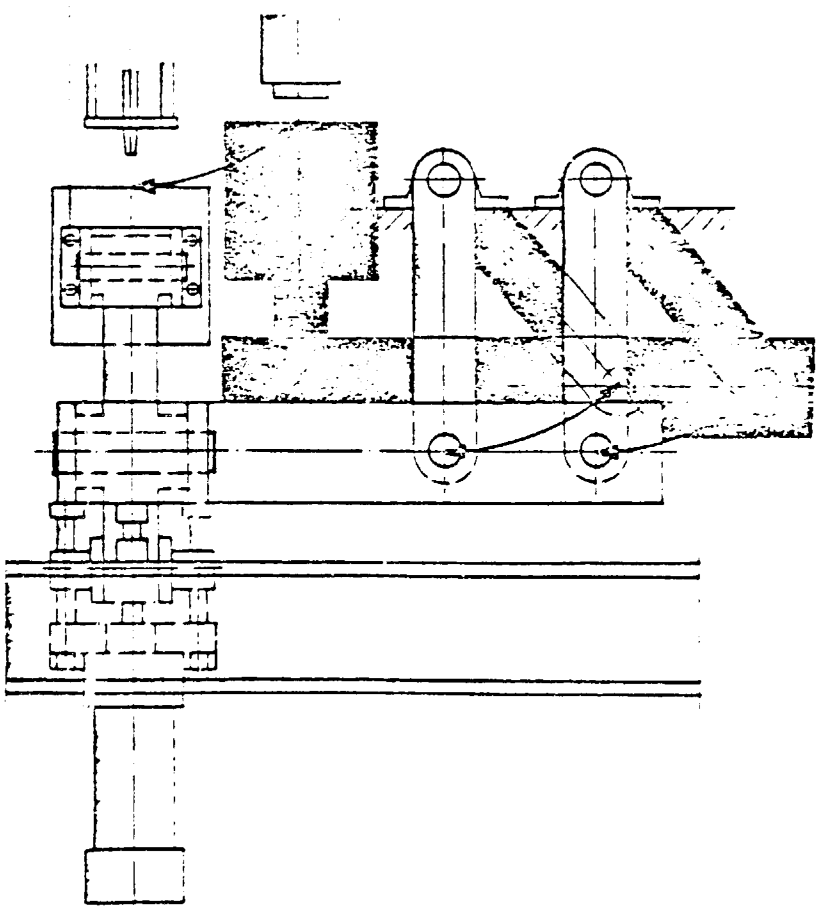
In continuous extrusion blow moulding, the parison emerges at a given rate from the die head. As soon as the mould has closed around the parison and the latter has been cut, the mould has to move away from the emerging parison to avoid collision with th mould. A wide range of blow moulding concepts and moulding transport systems are being offered. Shuttle design, horizontal as well as vertical rotation and the transport swing. All systems are geared to one aim: a high output rate.

Today's widely used and copied transport system for single and double station machines was developed by Fischer in the early 1960s, whereby the clamp unit is suspended on swinging arms. The complete clamp unit including the mould swings on an arc up backwards under the die head and down forward under the blowing and calibrating station. The system is operated by either an electro-mecanical brake motor or an hydraulic cylirder with propotional valve control. The transport motion must comply with a number of requirements: The quickly emerging parison requires that the mould decends downwards away from the following parison but at the same time the mould must move forward underneath the calibrating and blowing station. The motion must be fast in order to safe cycle time but towards the end position the speed must be slowed down to decellerate into the end position.

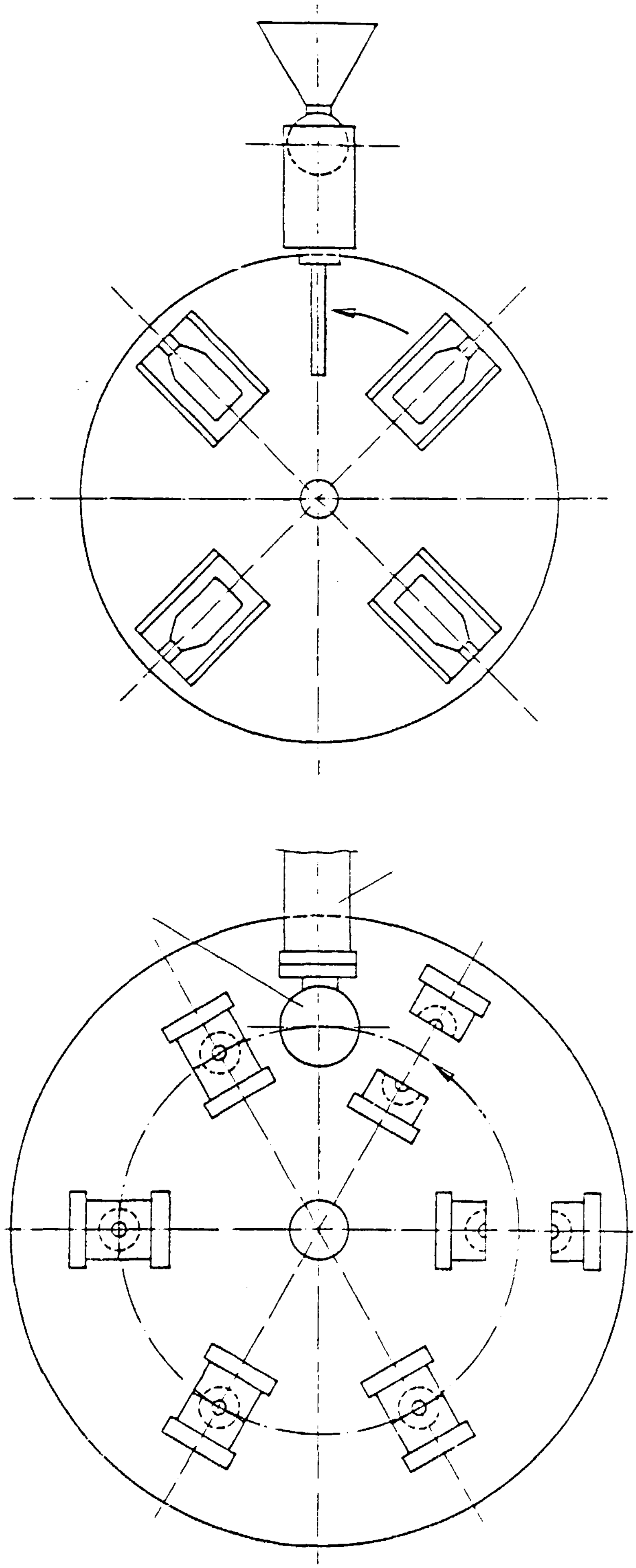
The gentle stop in the upper and lower end position is important for 2 reasons: first of all for the smooth running of the equipment, but even more important in order to avoid that the trapped parison slingers inside the mould and drops into it. For instance a parison for a 1.5 l drinking water bottle which is blown inside a neck has a parison length of approx. 350 mm. The weight is roughly 45 g. This instable parison is merely held by the bottom pinch and the mould neck insert, to be transported from the die head towards the blowing station. If the encushioning is not descillerating smoothly, the parison drops inside the mould and production is impossible.

Rotational mould carrying systems continuously move away from the emerging parison at a given speed, but here the mould has to be shaped in a particular way to avoid collision with the parison. However, rotational moulding machines are more single purpose machines for the inplant bottle production. They do not comply to the blow moulding equipment manufacturers' aim to achieve multi-purpose and flexibility. Blow moulders operating with accumulator heads also employ clamp unit transport to safe cycle time during the parison ejection.





14 Swinging movement of the clamping unit



ROTATIONAL CLAMP UNIT TRANSPORT
SYSTEMS HORIZONTAL AND VERTICAL

Calibrating and blowing device

The calibrating and blowing device has a multi-purpose function. The down and up motion is achieved by using an air or hydraulic cylinder. As soon as the mould holding the parison is positioned under the calibrating unit, the piston rod decends downwards. The latter is mounted onto the blow pin receiving brackett. By moving downwards the lower end of the blow pin enters into the calibration opening of the mould.

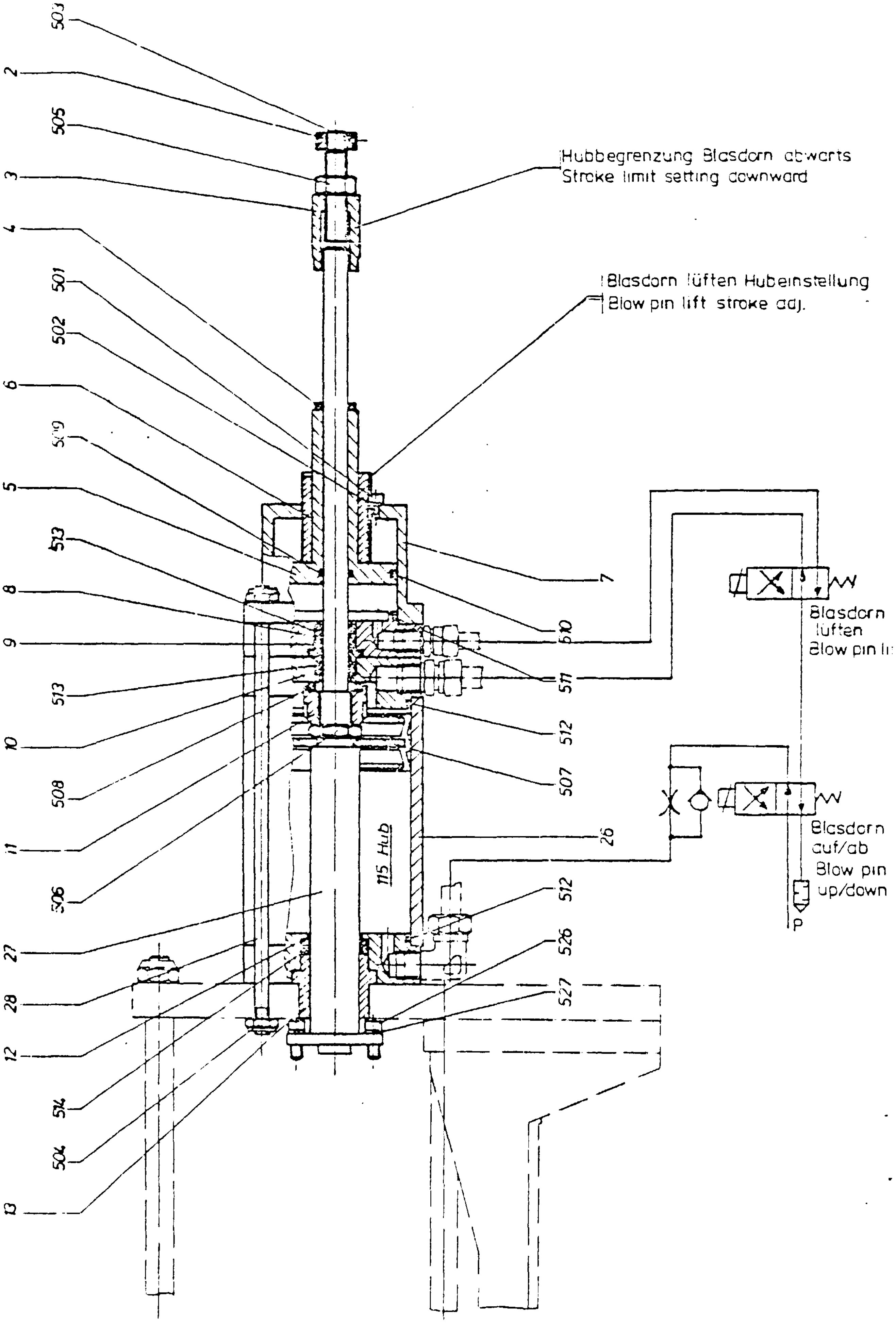
Just before the blow pin enters the parison inside the mould, the blow air starts to inflate compressed air inside the parison. The air stream opens the upper parison end to allow the entering of the blow pin into the parison which is held by the calibrating opening of the mould.

The blow pin tip calibrates i.e. forms the neck conture by pressing the polymer into the mould contures. At the same time the blow pin cutting edge located above touches the mould striker-plate to cut the excessive polymer above the neck area. So the top flash is separated.

During the blow time the blow pin stays pressed down so that the air pressure inside the container cannot lift the blow pin upwards. At the end of the blow time the compressed air is decompressed and released from the container. At this time the calibrating cylinder moves the piston holding the blow pin a specified stroke upwards to accomplish the following:

- rising the cutting edge away from the mould striker plate to avoid scratching and wear during the mould opening.
- loosening the tight-fitting blow pin tip to allow for a later article take-over as well as shortening the air-decompressioned face of the article.

When making the mould opening motion the blow pins acts as a demoulding aid to release the tight-fitting container from the mould conture. After the mould and article take-over mask have closed again, the blow pin rapidly moves upwards so that the next cycle can be initiated.



Hubbegrenzung Blasdorn abwarts
Stroke limit setting downward
Blasdorn lüften Hubeinstellung
Blow pin lift stroke adj.
Blasdorn lüften
Blow pin li
Blasdorn auf/ab
Blow pin up/down
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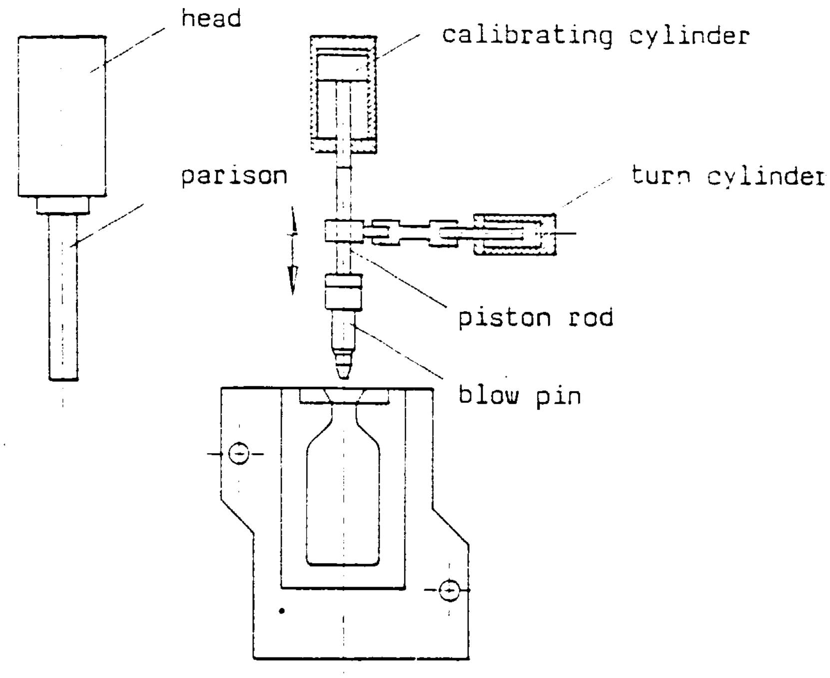
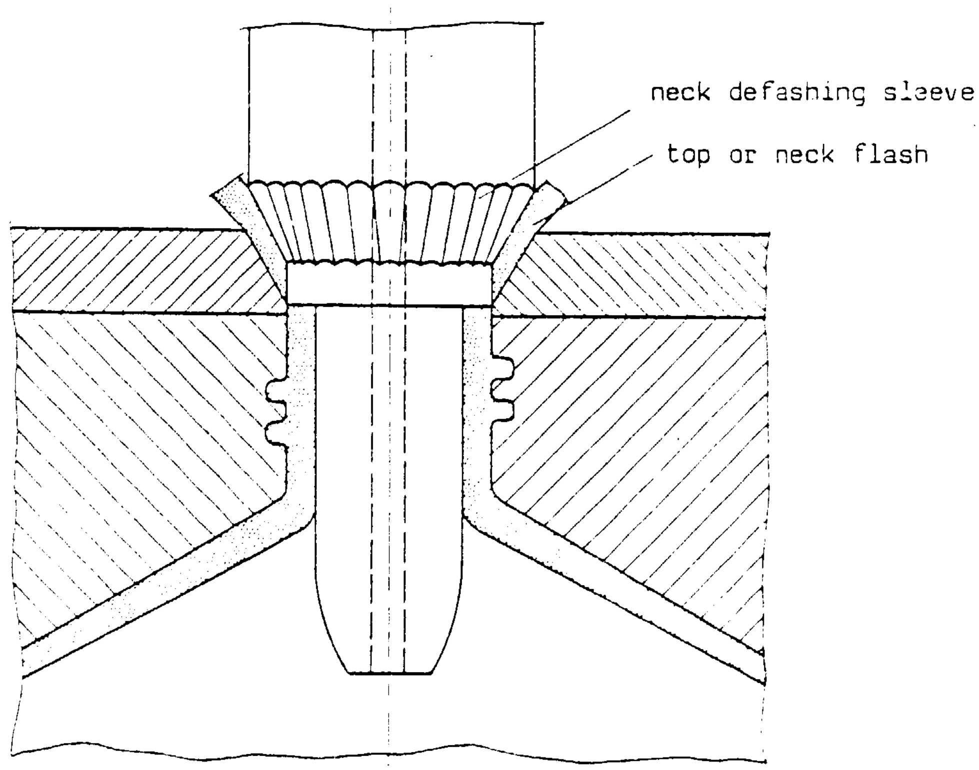




NECK CALIBRATION AND DEFASHING WITH TURNING [illegible]

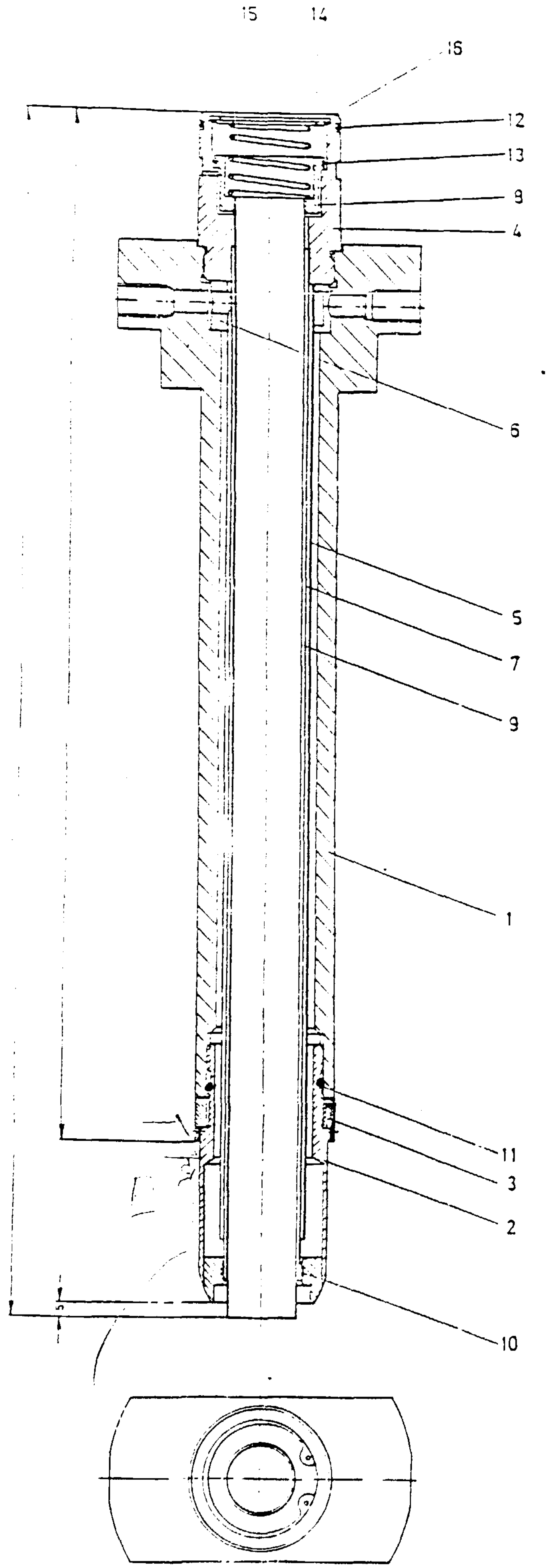
Blow pin

The blow pin basically consists of blow pin body, blow pin tip and blow pin cutting sleeve.

The calibrating tip and the cutting sleeve are taylor-made to a given mould calibrating opening.

The cutting sleeve diameter generally is 0.15 - 0.20 mm larger than the calibrating diameter of the mould striker platen.

The calibrating tip diameter is made up in a way ensuring the neck being formed properly and the article being safely transferred. If the calibrating diameter is too large, too much polymer is pushed down into the bottle neck by the penetrating blow pin. Should the calibrating diameter be too small, the neck is not calibrated properly and the bottle does not stay on the blow pin to be transferred into the proceeding processing step. Today's blow pin construction is fairly complex in order to comply with requirements expected from a good blow pin.



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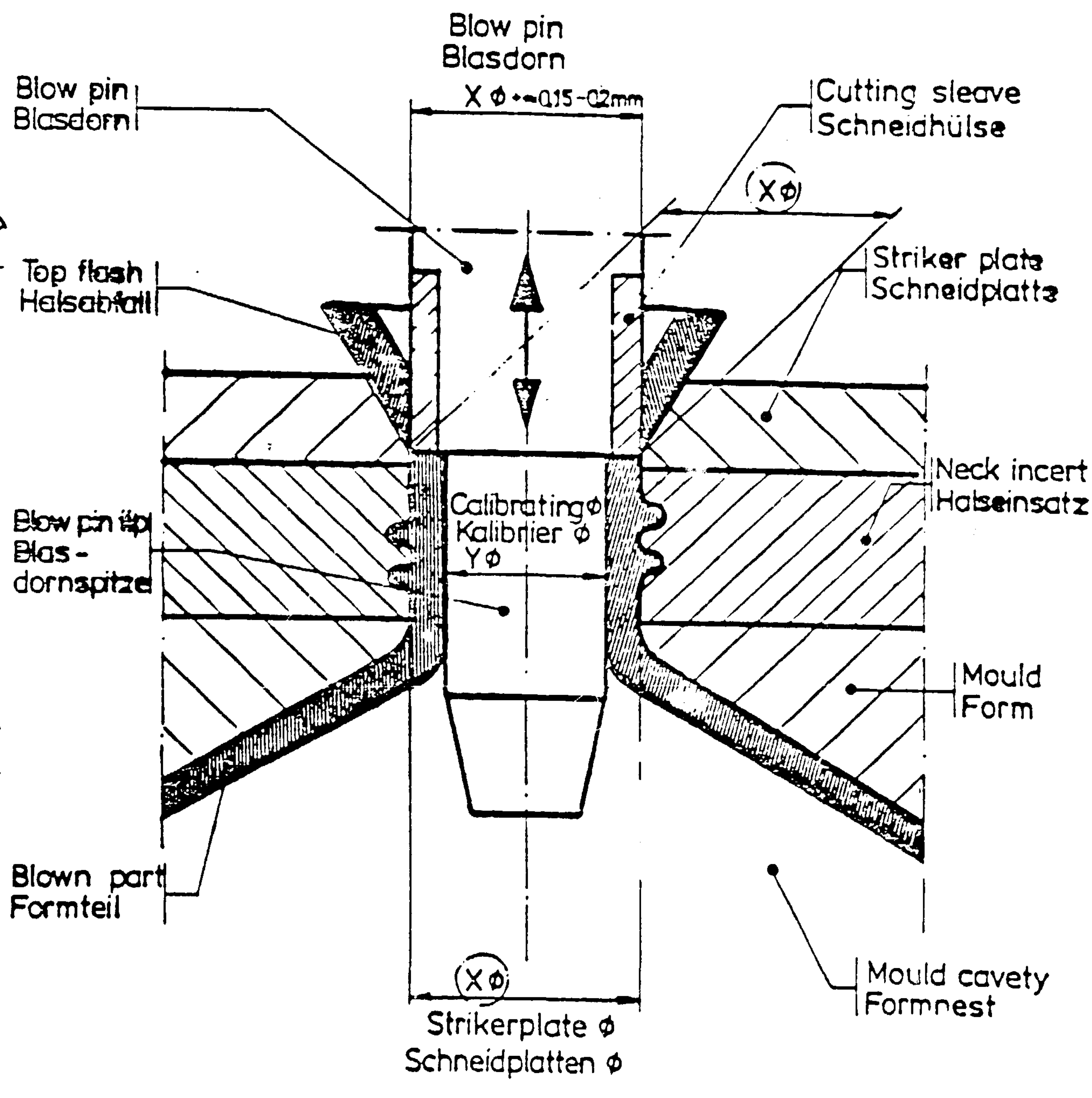
16
12
13
8
4
6
5
7
9
1
11
3
2
10

The blow pin tip is in direct contact with the concentrated amount of polymer in the neck area. Here the cooling has to be very intensive. Therefore a direct contact wit the cooling-water must be provided.

The cutting sleeve continuously hits the mould striker plate, is a wearing part and must be replaceable easily and fast, without removing the blow pin. Once the blow pi is removed after replacement, it must be readjusted to the blow mould.

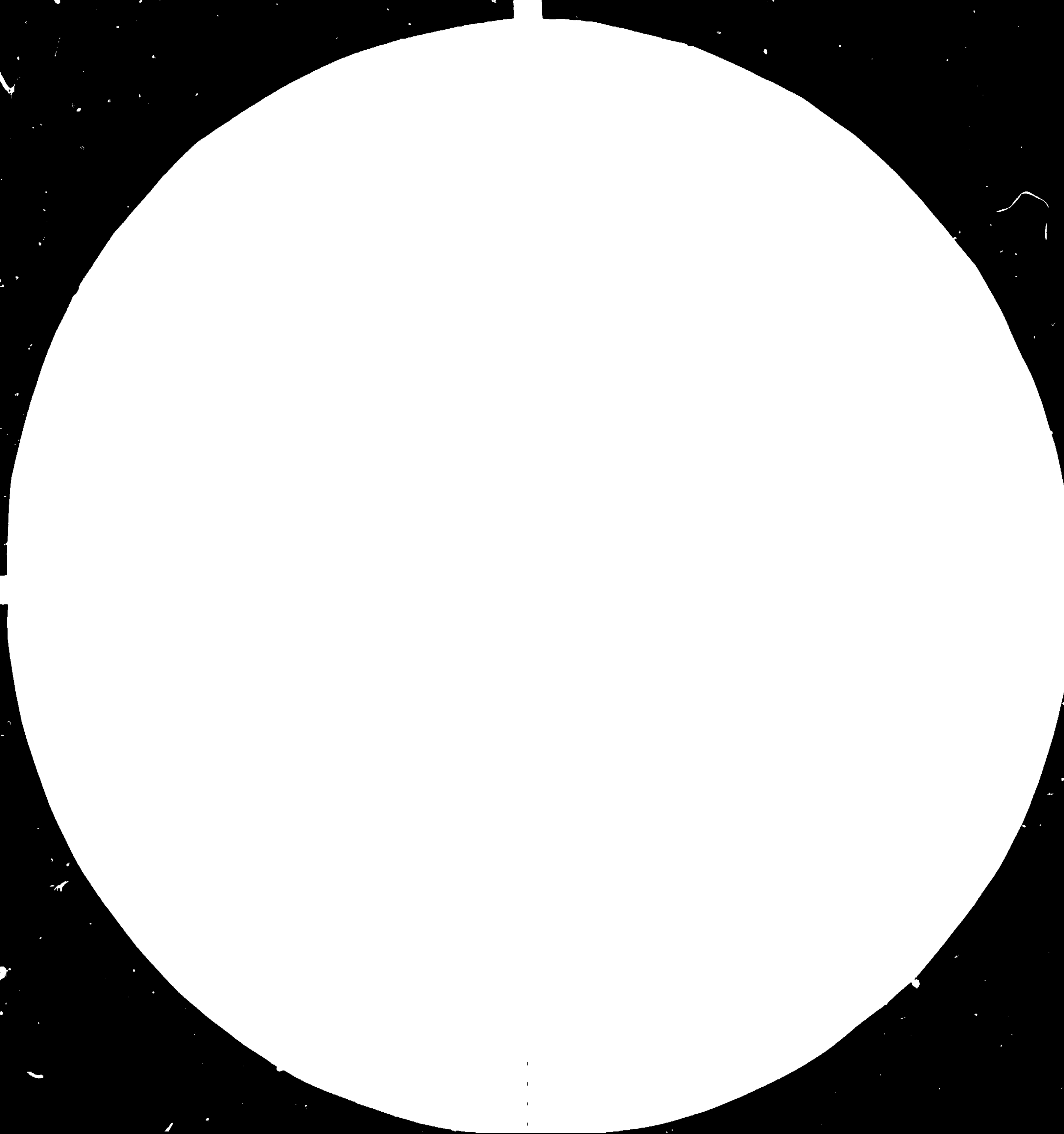
Blow pin body

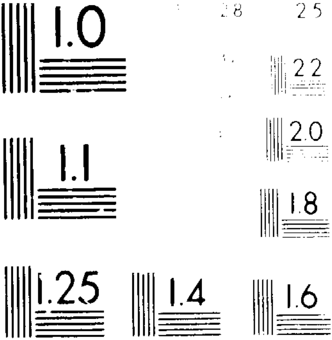
The blow pin body consists of an outer conture with a receiving adapter and the threaded cooling-water in- and outlet connections as well as the blow air inlet through the centre. Inside the blow pin body a number of different brass pipes diameters inserted into each other conduct the cooling-water down the outer blow pin diameter, striking the blow pin tip to return on the inner pipe to the outlet. The blow air passing through the spring-loaded centre pipe builds up pressure inside the article to expand the polymer to the mould conture. An overflow-channel created by an additional brass pipe allows a controlled and constant flowing of air towards the blow pin receiver and out through a silencer into the open air. This feature provides a constant exchange of cool air into the article and helps to shorten the cycle time. The spring-loaded centre pipe acts as a buffe so that the incoming air cannot immediately return to the outside. At the same time the centre pipe must allow to insert an Allen key to remove the blow pin tip in order to replace the cutting sleeve.



Neck-kalibration

Halskalibrierrung




1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

Blow Moulds

Blow Moulding tools represent the negative of an article to be produced. They are manufactured from steel, aircraft aluminium, copper-beryllium or casted from Kirksite, (which is the tradename for an aluminium-zinc combination). The different mould materials are used for their specific characteristics, such as heat connectivity, hardness, machineability and mouldability.
Moulds are machined, casted or a combination of both, to combine the good mouldability of the casting with the machined and hardened cutting edge. These mould parts combinations are widely used in the production of automotive parts or technical items.
Moulds for bottles, handle containers, jerry cans and drums are sub-devided in 3 mould sections: neck, body and bottom section.
Each part has a separate cooling circuit to control the cooling intensity.

Mould cooling

Mould cooling is the most important aspect in blow moulding. Without a good cooled mould, the most modern and fastest moulding machine will have bad production record.
The first criteria is, to select the right mould material or material combination for a given container.

Mould materials:

Steel can be machined, hardened and welded. Cutting edges from steel stand up for long production runs but the heat connectivity it relaively poor.

Aircraft Aluminium combines the good heat connectivity and good machineability, but the heardness of the material is not sufficient to build cutting edges, which stand up for a long time.

Copper-beryllium combines the 2 main features, heat connectivity and long lasting tough cutting edges, but the machineability is poor and the material is very costly.

Kirksite is a metal combination of aluminium zinc and different flow stabilizing agents, which combines good mouldability, heat connectivity as well as machinability.

Kirksite is used to cast moulds of mostly complex surface contures and large sizes, however cutting edges from Kirksite have a relativly short life time, therefore casted moulds have a steel insert at the cutting edge. The mould cooling capacity must be more intensive in the mould sections where the product has a polymer concentration. Here a large amount of heat must be transferred from the polymer through the mould wall into the cooling water.

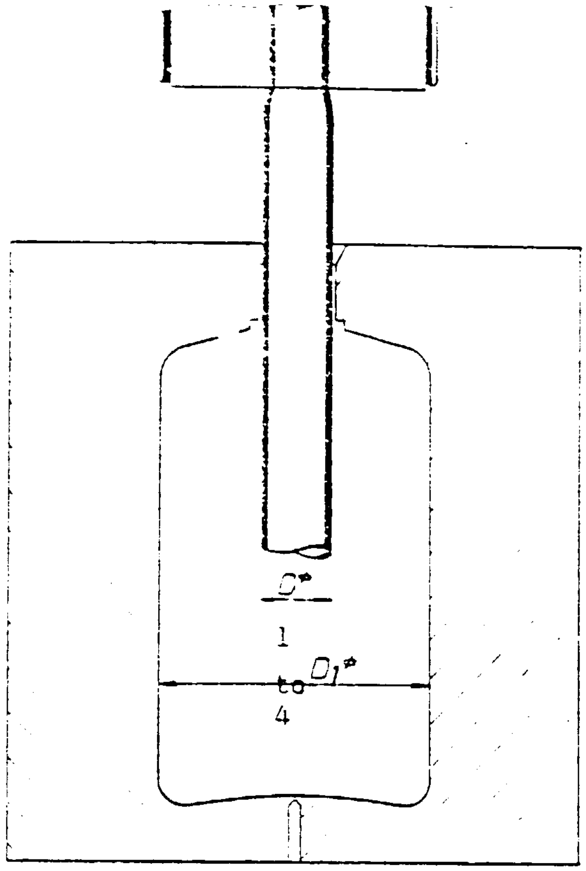
In container production, ranging from small bottles up to large drums the polymer concentration is in the neck and bottom area. This is also the area, where the cutting edges are located to weld the parison together and separate the flash from the product.

Depending on the product design it must be decided which mould material is suited best for the job.

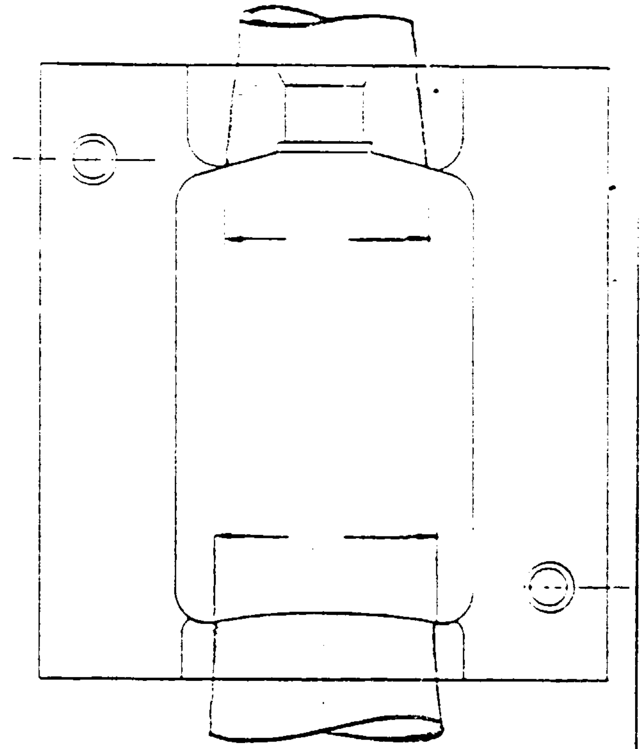
If the mould has an accumulation of cutting edges in the neck-, handle- or bottom area, steel would be the answer, but the cycle time is longer.
For high output and fast cycle time, copper-beryllium would better serve the purpose.
In the mould body part, the polymer concentration per area is usually less.
If there are no cutting edges, aircraft aluminium could be combined with the top and bottom section made from different materials to achieve a good cooling and reduce the overall weight of the mould.

The mould cooling channels are drilled or milled grooves along the cavity around the neck and through the mould bottom section.
The cooling channels must be designed in such a way, that no dead areas are being created and the residence time of the cooling water in the channel is short.
The water flow rate should be high and the cooling channels short.
So the cooling water temperature is not increased more than max. 3-4° C between inlet and outlet temperature. The common temperature difference is between 1 and 2°C. In order to assure a high cooling water flow rate, a pressure difference by at least 2,5 - 4 bars between mould inlet and outlet must be provided. With a high flow rate a turbulent water flow inside the cooling channels is created to eliminate insulation water layers and a better heat transfer is accomplished.
The cooling water´s channels diameter depends on the mould size up to 10 litre containers the whole diameter is selected approx. 11 mm dia. at the same time to fit a tap for a 1/4 " pipe thread connection.

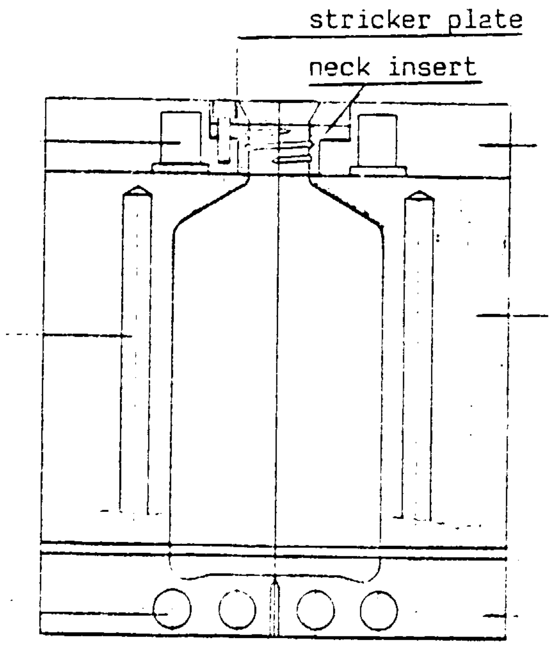
The cooling channel distance from the cavity to the water flow channel should be 0.25 - 0.50 and the distance from one cooling channel to the next one should be approx. 0.5 to 0.8 of the hole diameter. If the cooling channels are located too close to the cavity surface, the cooling might partially be too intensive and can create an uneven product surface. If the cooling channels are situated too far from the mould cavity, the cooling is not intensive enough. Casted moulds have a copper pipe cooling system, made up to the product conture and casted-in. So the cooling intensity is almost even. In areas where more heat must be removed, more cooling pipes are build in.
The water cooling connection onto the mould should be made in such a way that the incoming water is always at the lowest point. That way, it is assured that even with a bad cooling water flow, the cooling system is always filled. It is also important that the fittings and hoses do not restrict the water flow.



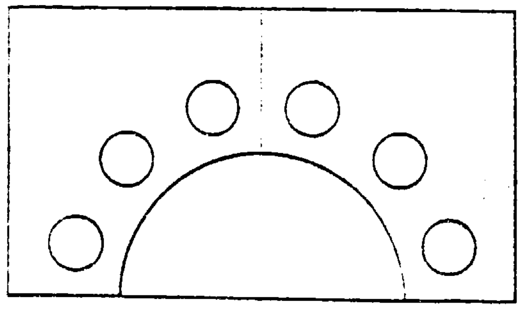
parison inside the neck
blow up ratio 1:4



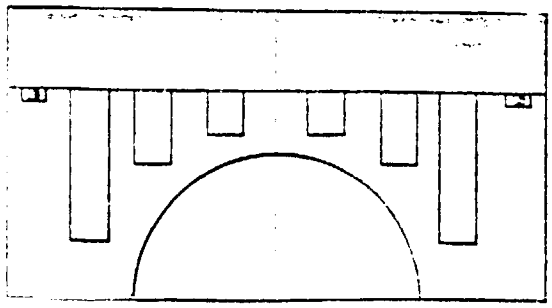
parison outside the neck
b.u.r. more than 1:4
or for ovalized bottles



neck-body-bottom cooling



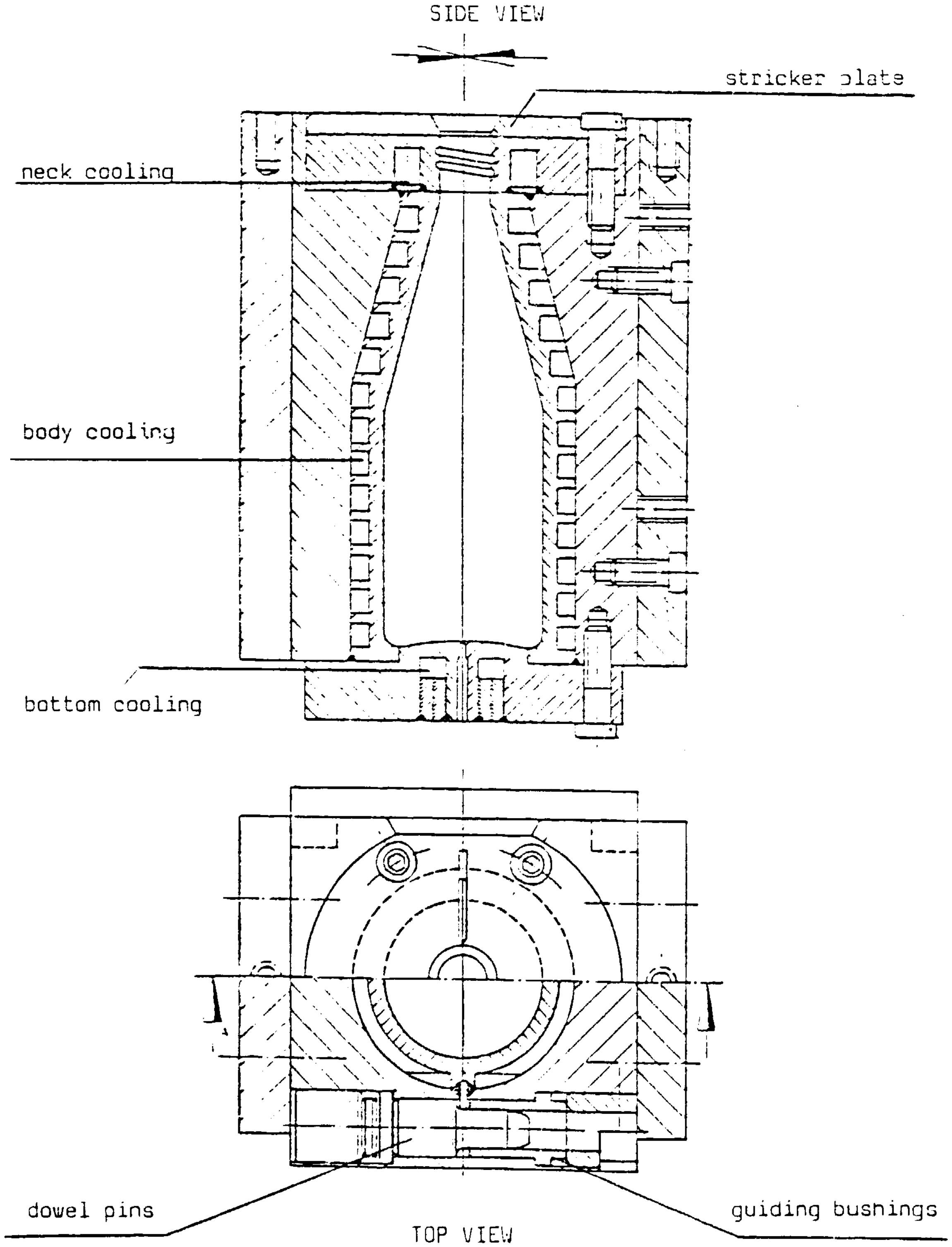
drilled cooling



milled cooling

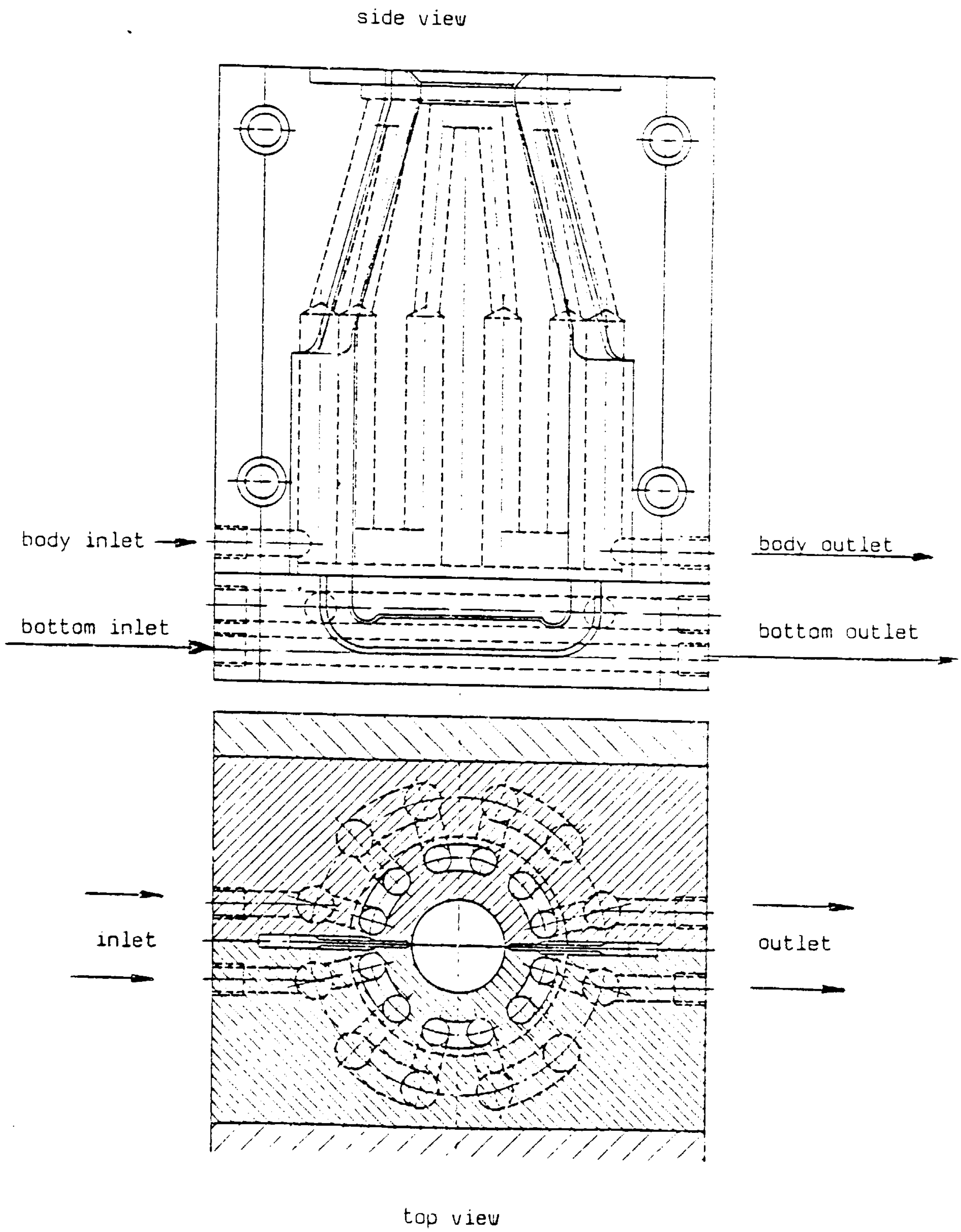
MOULDS

ROUND CONTAINER



MOULD COOLING I

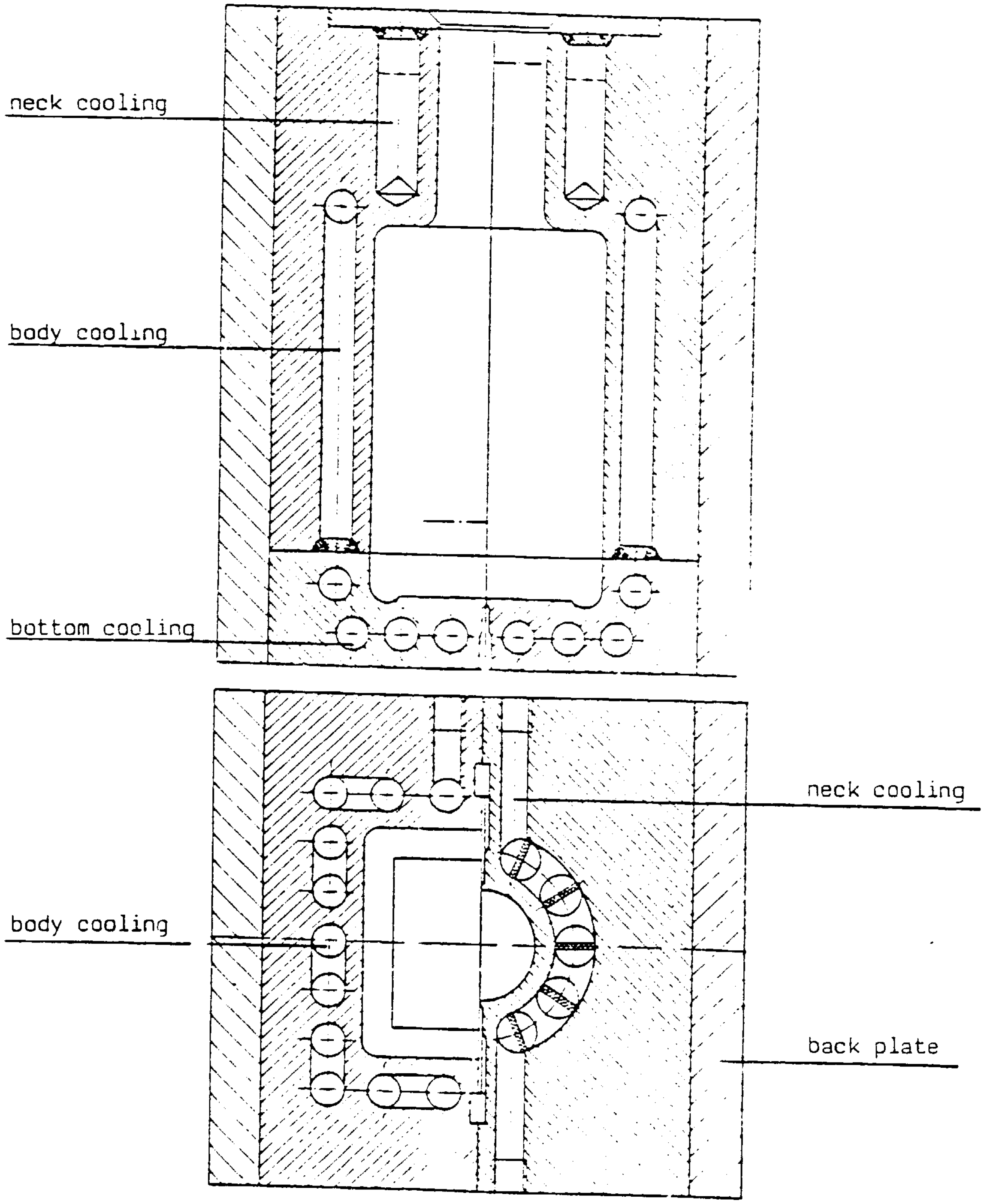
ROUND CONTAINER



MOULD COOLING II

SQUARE CONTAINER

side view



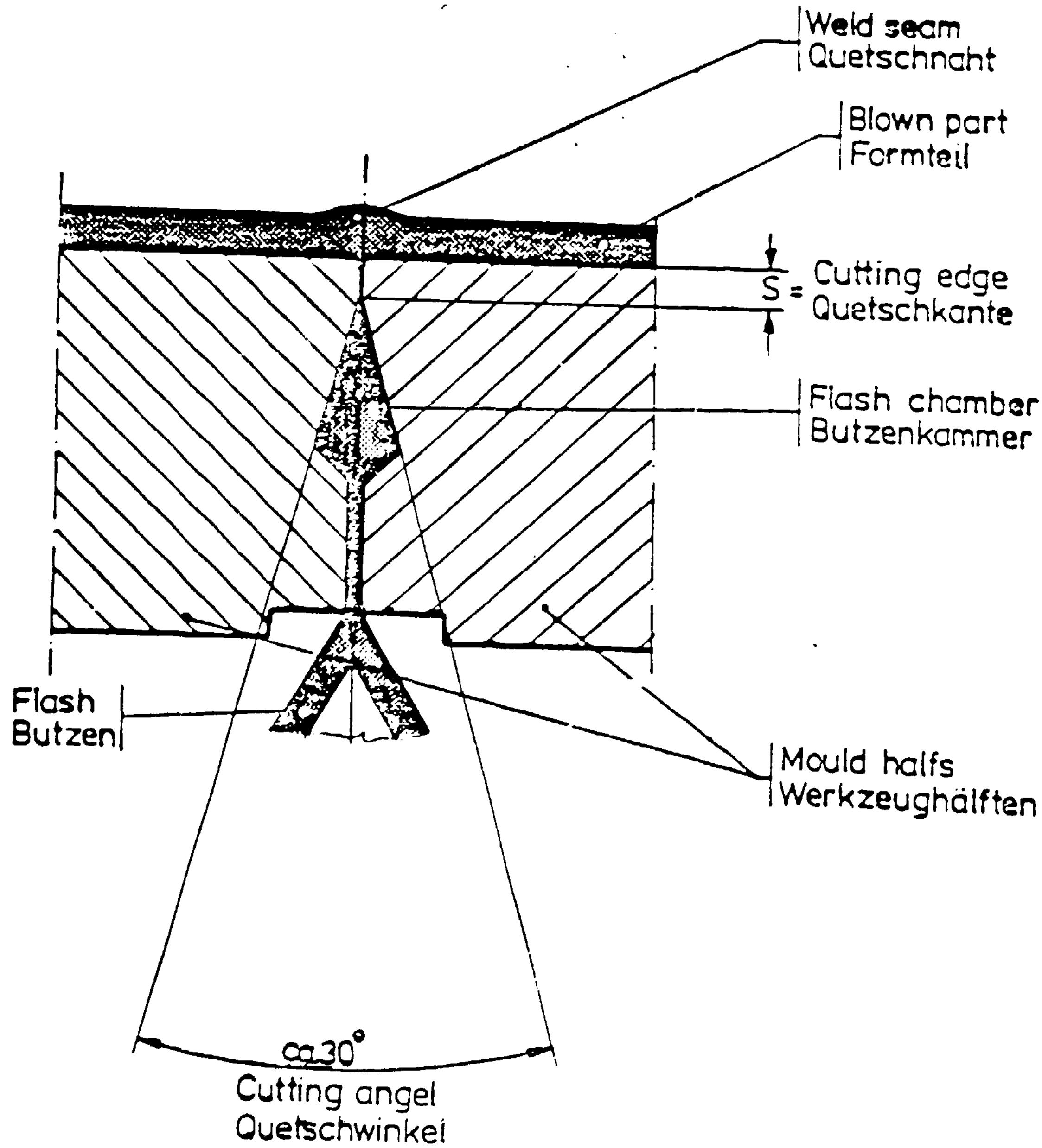
top view

MOULD COOLING III

Cutting edges

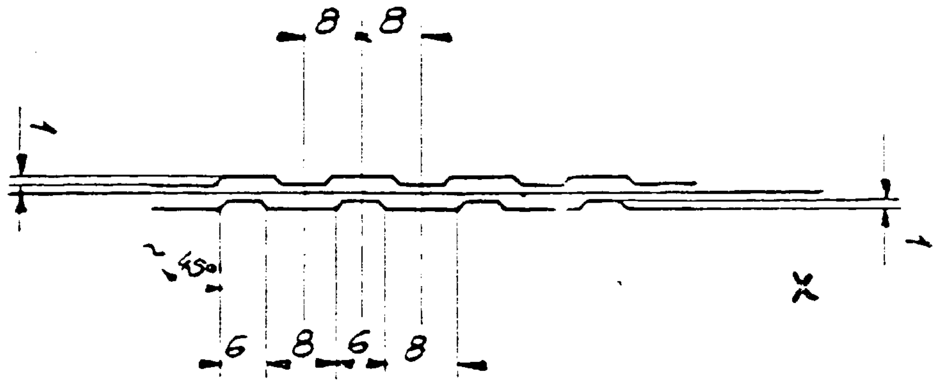
Cutting edges are located on the mould where the extruded parison is being pinched, rejoined and cut. For bottle production where the parison is received inside the mould neck area, the weld-seam is only in the bottom section. Articles blown outside the neck where the parison is received and pinched to both sides of the neck insert have also welding and cutting edges on the bottle shoulder. Handle containers and jerry cans are also welded in the grip or handle section. The cutting edge dimension "S" depends on the the container size and the processed polymer. PE bottles up to approx. 2 litres contents have a "S" dimension (of 0.2 up to 0 4 mm) and a cutting edge angle of 30 up to 45°.
Polyproplyene and PVC require a much sharper cutting edge.

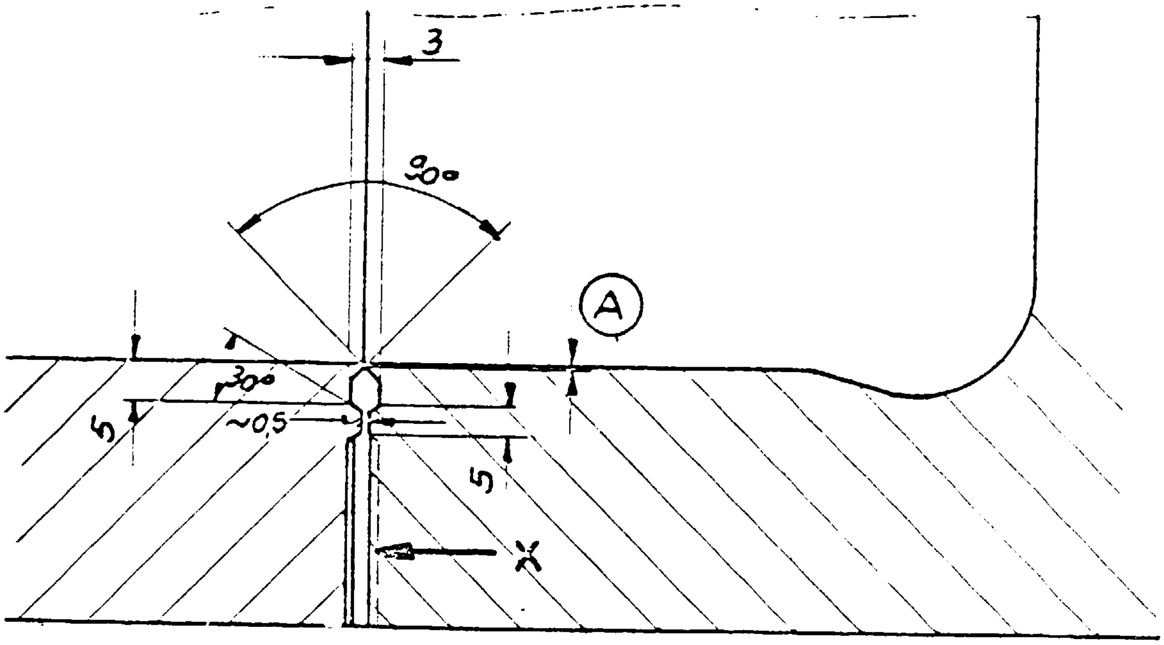
If the cutting edge is too sharp, the closing mould will produce a poor welding but a good flash separation. Whereas a flat cutting edge produces a strong weld-seam but a very bad cut in conjunction with the final mould closing speed. So the cutting edge on the mould must be made to serve both purposes, good welding and good flash separation. A variaty of cutting edge executions is being offered from different mould makers and machine manufacturers. All are serving the same purpose. Today there is not absolute design.

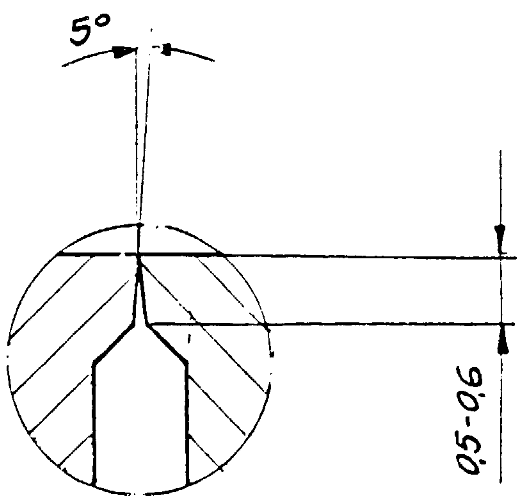


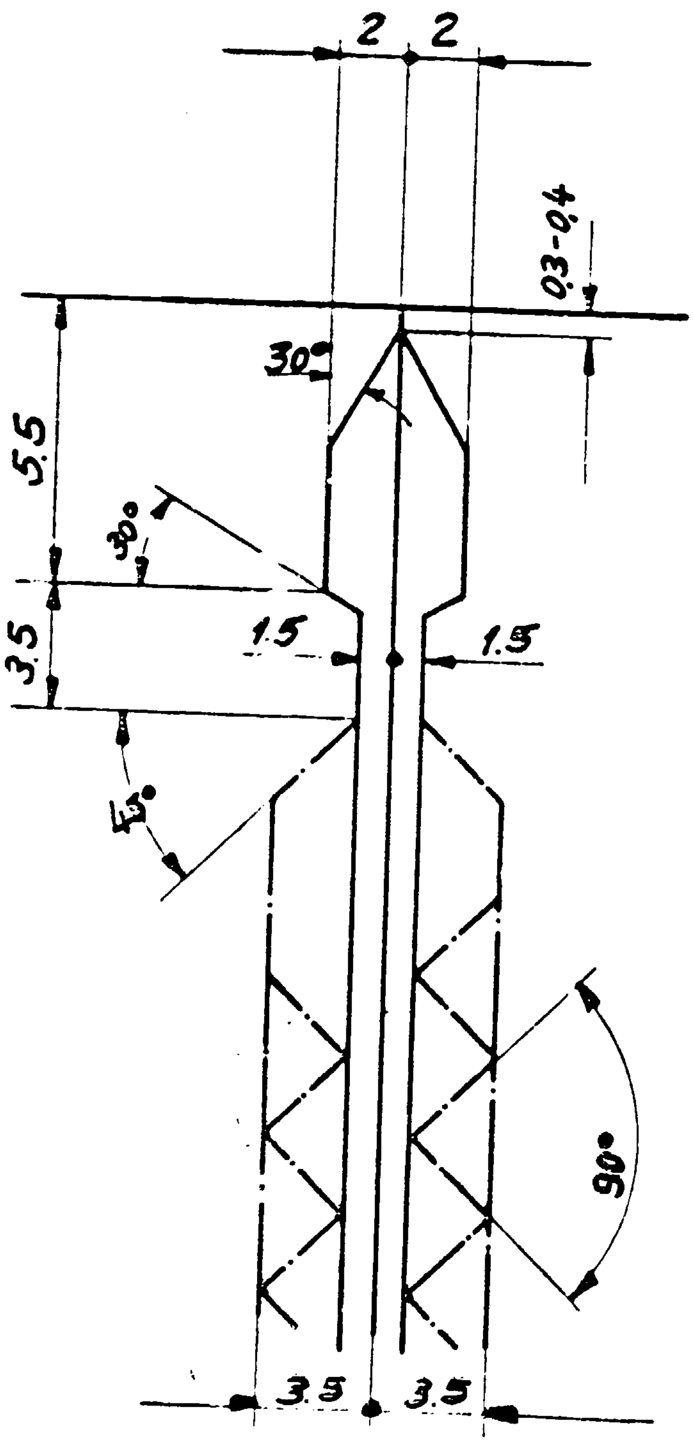
Bottem weld seam
Bodenquetschnaht

[redacted]


8
8
1
1
~45°
X
6
8
6
8

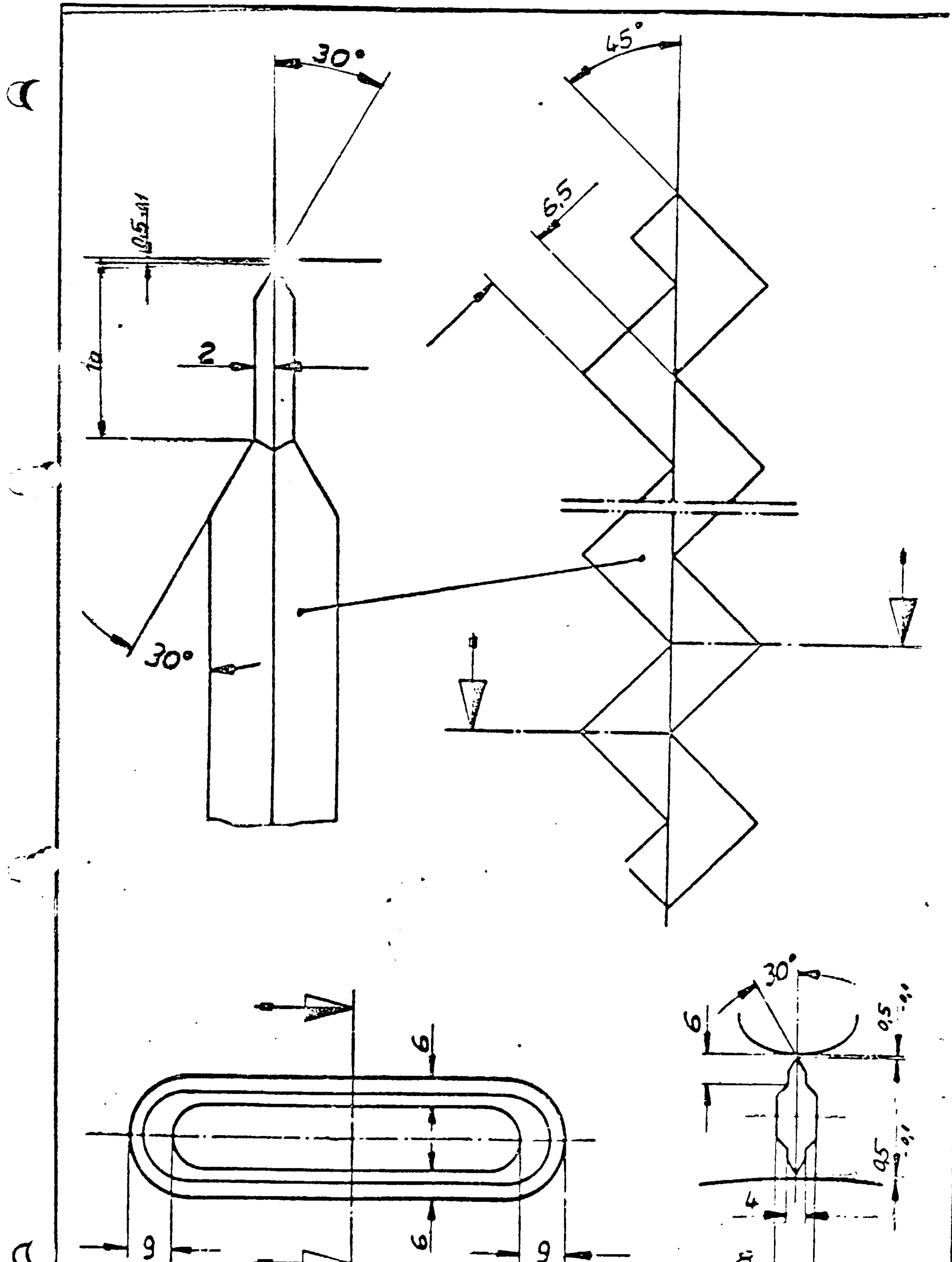

3
90°
A
30°
5
~0,5
5
X


5°
0,5-0,6

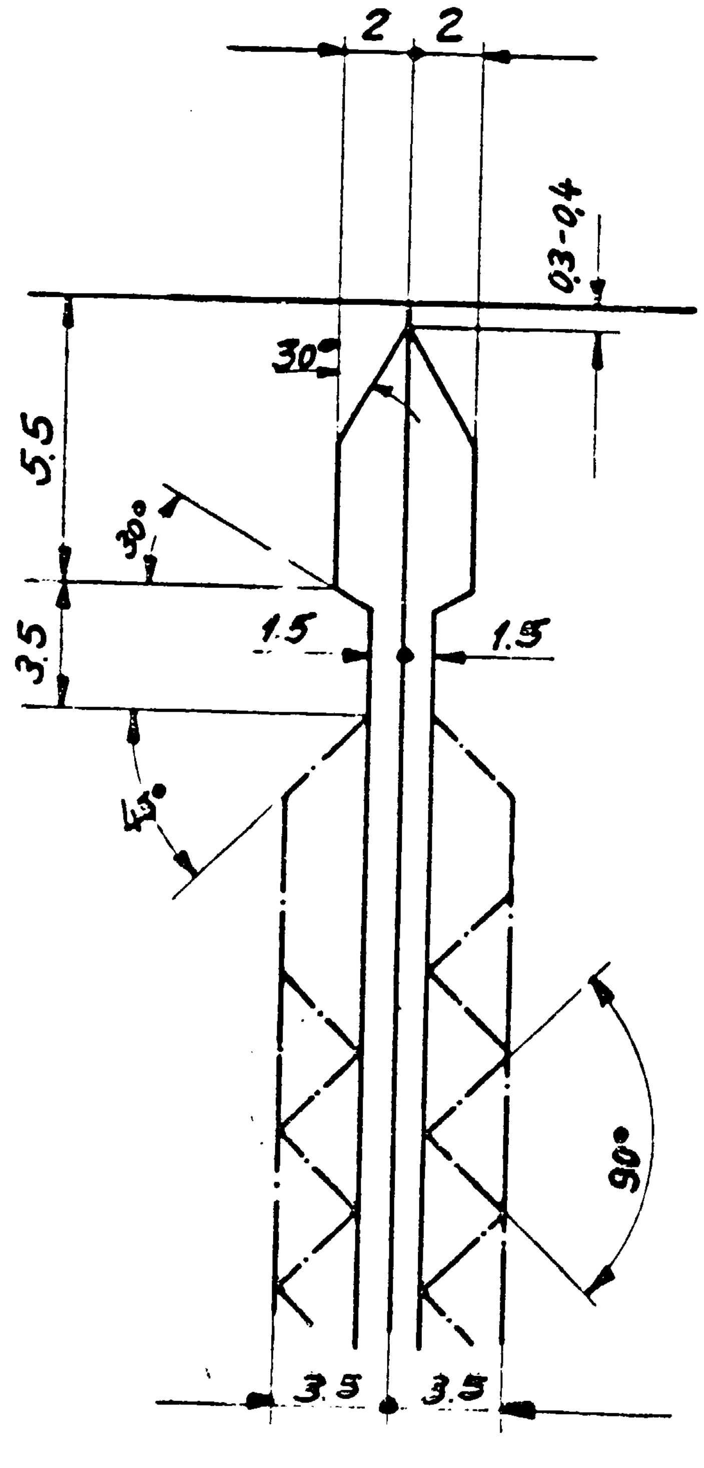


Cutting edges for PP up to app. 5 l.

Schneidkanten für PP bis ca. 5 l



Cutting edges for PP up to app. 30 l.
Schneidkanten für PP bis ca. 30 l.



Cutting edges for PP up to app. 5 l.

Schneidkanten für PP bis ca. 5 l

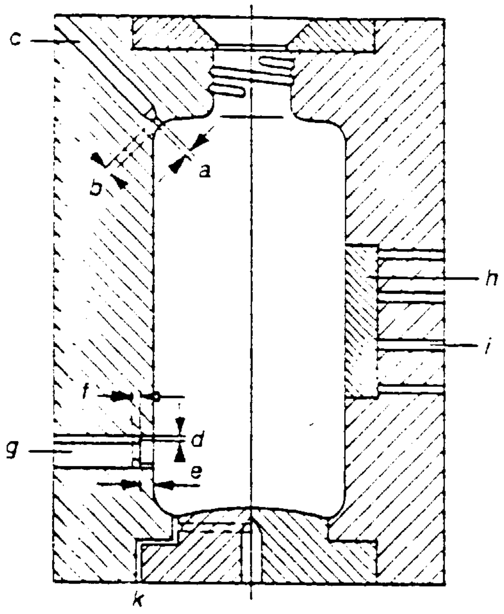
Mould venting

Venting of the mould cavity is important for a good parison-mould surface contact and the optical surface appearance of the product. The closing moulds traps the parison in between the two mould halves. The air trapped between the parison and the mould wall must be vented to allow the expanding parison to reach the cooled mould surface.

Symetrical round container moulds are vented in the mould parting line by grinding grooves of approximately 0.04 up to 0.08 mm into one mould parting line. If the venting channels are too deep, the relief will be noticeable or a hole might be blown into the article parting line.

Unsymetrical mould contures are vented by drilling a hole from behind close to the cavity surface and a small hole is opened into the mould surface or sinter-metal porous insert with slots or small holes are pressed into the cavity to relieve the trapped air. Milled or ground channels in the rear platen relieve the air into the atmosphere.

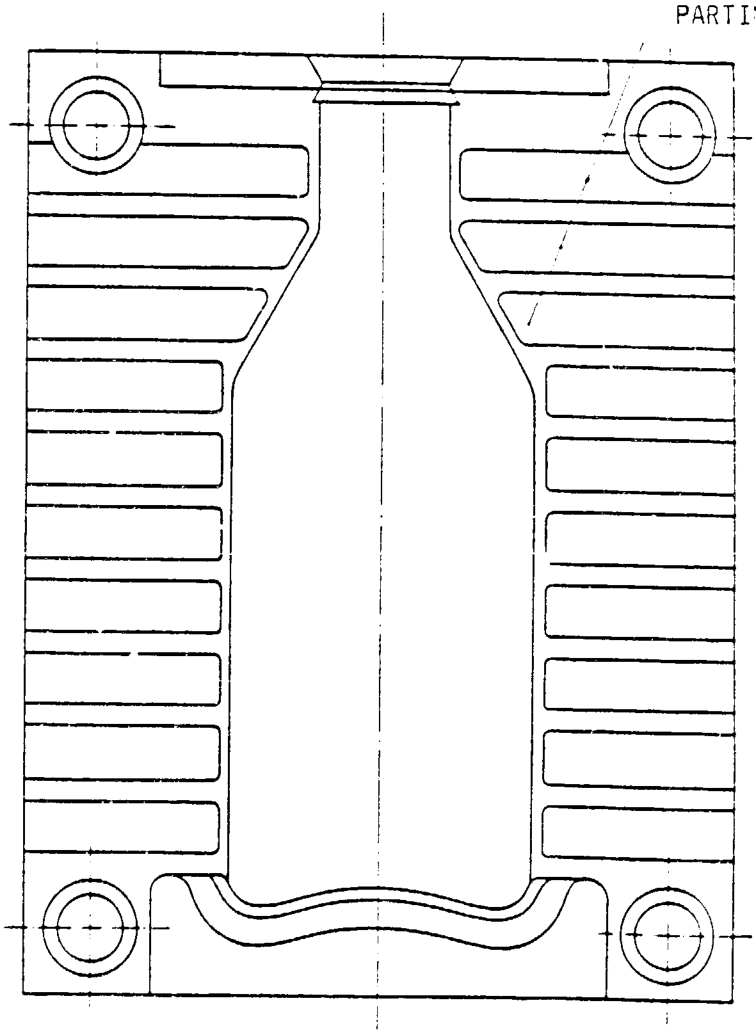
CAVITY VENTING
FROM THE REAR



engraving plate inserts

letters are vented
to avoid air entrapment

CAVITY VENTING IN THE
PARTING LINE



cutting edge

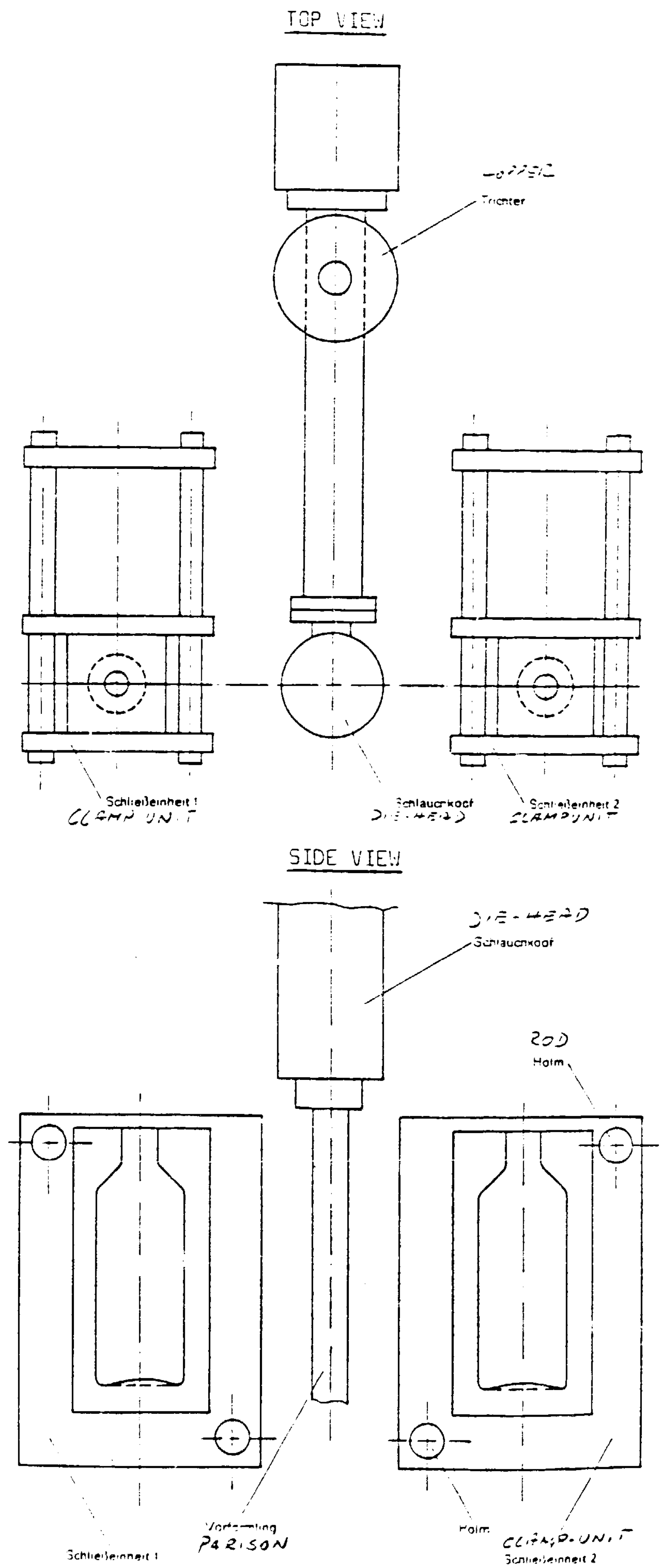
free milling

MOULD VENTING

Mould aligning pins

Aligning or dowel pins are located in the four corners of the mould to align the two mould halves which avoids a mould off-set. The ~~dull~~ pins should engage into the opposite mould half by appr. 0.8 to 1 times of the dowel pin diameter. If the aligning pins reach out too much they can interfere with the demoulded container. Too long dowel pins restrict the mould opening stroke.

The dowel pins bushings located in the opposite mould half should be drilled all the way through to the rear platen to allow trapped plastics particles caught by the dowel pins to be pushed towards the mould rear. A bunk hole or sack will fill itself soon with plastic and the mould will not close. Depending upon the mould size, the dowel pins have different diameters up to appr. 2 liters the diameter is 12 to 15 millimeters diameter dowel pins up to 45 millimeters diam. are quite common for drum moulds up TO 220 l.



Double station blow moulder

PROCESSING INFO.

Process technology

The parison emerging from the die must have the correct temperature. Is the stock or melt temperature too high, the parison will sack or draw down caused by the gravity due to the polymer weight. The parison will thin out at the top and thicken towards the bottom. Is the melt temperature too cold, the parison will not expand evenly. The pressure built up inside the head and the extruder can rise to a dangerous level to harm the equipment.

The correct temperature setting starts at the extruder, if for instance the temperature in zone no. 2 is risen, the polymer starts to meld sooner, therefore a longer time and more srew flights are available to mix the material. This in turn can change the complete temperature behaviour and consistency on the emerging parison.

The sack or draw-down can be compensated to some degree by gradually increasing the die-gap during the moulding cycle, but this requires a parison programming control.

Processing of PVC

PVC is a thermo sensitive polymer requiring skillful processing adjustments and operation. The required processing temperature setting on the different heating zone can only be given in approximate range. It depends on varying material characteristics i.e. charges, supplier and extruder type. The final temperature profile must be found step by step until the right physical properties and consistency are being obtained.

Before start-up

The extruder barrel and the die head require a pre-heating time of at least 1 or 1 1/2 h, depending on the extruder size and die head. The pre-heating time can go up to 3 hours. During this time the temperature control for each heating zone should be observed to check whether the temperature is rising to the set point.
Extruders for the processing of PVC are equipped with fan-cooling up to 60 mm screw diameter. Larger extruder sizes have an oil tempering circuit to remove the excessive frictional heat. If oil-cooling is used on the extruder barrel the tempering unit should be switched on at the same time.

Start-up

Before pressing the button to start the extruder all temperature settings have to be double-checked to avoid a cold start-up. During the start the extruder rpm indicator and the motor amp meter must be observed closely to determine whether the motor is overloaded. If the start-amperage has not dropped to normal running load within app.ox. 5 sec, press the stop button and check the course.
In the beginning the barrel temperature is slightly higher than the screw temperature and the plasticised PVC material does not yet have the correct temperature consistency. For that reason the extruder should be started at low rpm (approx. 25).

The rotating screw creates friction heat and the temperature on the screw surface increases. After a short time span the milky colouring of the PVC will disappear and the parison will be transparent. At that time the internal screw cooling should be opened (the gage should read approx. between 1 and 3 bar) and the screw rpm should be speeded up to the required parison output rate.
Overshooting of the temperature indicator for the barrel means excessive frictional heat.

Extruders for the processing of PVC ranging from 35 mm up to 60 mm screw diameter are equipped with fan-cooling. Large extruder sizes ranging from 70 mm up to 100 mm screw diameter have an oil tempering circuit to remove the excessive frictional heat.
Before the flow control valves at the barrel cooling are opened to remove more frictional heat, the processing temperature should be increased slightly to reduce the polymer friction. Be careful to avoid the critical temperature range so that the polymer does not decompose.
The oil-cooling for the barrel should have an incoming temperature of 60° - 80 ° C.
Temperature corrections for heating as well as for cooling should be carried out in small steps to allow the system to stabilize itself. For instance - if the temperature of zone No. 2 is increased, the polymer starts to melt sooner and because of this more time and screw flights are available to mix and homogenize the PVC before it enters the head.
A cloud formation in the produced bottle can be rectified this way. If the stock or melt temperature is too high, flow lines from the torpedo spider legs are visible. The stock or melt temperature for different grades of impact modified polymer ranges from 190° to 210° C. A different temperature setting is needed for different amounts of regrind as well as the physical size of the regrind particles mixed with the virgin material.

Shut-down

When the extruder is shut down all the PVC in the feed section of the hopper must ru out until the screw flights are cleared.

The extruder is then purged with low density polyethylene (LDPE).

Low density polyethylene is inserted into the hopper and the temperature is decrease to approx. 110° - 220° C. The remaining heat in the barrel and head is sufficient to extrude the LDPE through the system for approx. 5 - 10 minutes at low extruder rpm.

After approx. 10 more minutes the LDPE and the rest of the PVC in the system merge.

The extruder should be started again in order to purge this mixture out of the system.

Start-up after shut-down

By re-starting the machine the rest of the low density in the system must be extruded until the screw feeding flightss are cleared. Then PVC is put into the hopper. By doing so the period of transition from LDPE into clear PVC is kept short. If the PVC is put into the hopper too soon, it mixes with the LDPE still in the hopper, thus increasing the period of transition.

At first a mixture of LDPE and burned PVC spots resulting from the remaining PVC in the barrel during the pre-heating time is extruded. As soon as the screw picks up friction heat the parison becomes clear and the temperature as well as the polymer mixture become consistent.

Barrel cooling

In order to eliminate the friction heat created by the rotating screw, barrel cooling fans are privided for extruders up to 60 mm screw diameter. Larger extruder barrels are separately provided with an oil cooling circuit. Pre-heated oil with an inlet temperature of 60° - 80° C is circulated through the barrel cooling circuit.

When the temperature control indicates an overshooting of the processing temperature the heat is cut off and a cooling fan or solenoid for the individual barrel zones is energised. The cooling medium flows through the cooling jacket to absorb the excessive heat. The oil cooling system is connected by a heat exchanger to the cooling water. The 60° - 80° C cooling oil provides a smooth temperature profile which results in a good quality of the product.

Alternatively other cooling media can be applied.

By using water as the cooling medium the processing temperature fluctuates around the set point in uneven intervals. Steam created by the high temperature also clouds the flow channels within a relatively short time.

Compressed air is also used as cooling medium. However, it is very expensive.

Double head production

When employing a PVC double head the polymer flow velocity from the screw root and barrel surface must be the same. Proper screw tip cooling is most important. If the die gap is even at the surface the 2 parisons will crawl to the outside if the temperature is too high. Both parisons crawl towards each other when the screw tip is too cold (too much screw cooling). Equal parison length at both heads is achieved by setting different processing temperatures for the appropriate head zones.

Processing of PC (polycarbonate)

Basic properties: high impact strength, heat resistence, high tensile strength and glass like transparency.

Handling characteristics: polycarbonate is generally processed with blow moulders equipped for PVC production, the material has a very high shear resistence, its flow is almost completely controlled by the temperature.

Extruder: The heating zone temperature of the extruder barrel must be closely controlled. The feet section should be water-cooled to prevent fluctuation or clogging. The srew with compression ratio of 2 or 2.2 : 1 gives good production results. The depth of the feeding flight should not exceed 3 up to 4.5 millimeters depending upon the srew diameter.

The head with streamlined flow channels and two spiderleg torpedo allows an even material flow (sharp edges and undercuts will create hang-ups).

The diehead should have a smooth polish surface and be designed to allow an even melt flow. The die and core should end at the same level.

The landlength is 10 to 15 times the diegap, but should not exceed 25 millimeters of length.

The parison cutting device to separate the polycarbonate parison must be a hot wire cutter. The cutting wire should be dark-red heated.

The mould with a smoothed polished surface will produce a good quality container. Moulds must be vented in the parting line. Sharp edges and undercut should be avoided because the compressibility of PC is extremely limited.

Mould pinch off

To assure a good strong welding seam, mould pinch offs should be designed with an included angle of 30° to 45°. Welding seams should be maintained between 0.2 to 0.3 millimeters.

Processing: Predrying of PC resin is essential. The material must be dried prior to processing to avoid degration and eliminate bubbles which result from excessive moisture. It is necessary to keep the moisture content below the 0.2 % during processing to achieve optimum properties. Even if the resin may be dry packed in sealed containers, a preheating time of several hours by 120°C may be required. The use of a constant feed hopper dryer is recommanded.

Start up

The temperature should be set 10 to 20 degrees hotter during start-up as for normal operation. To reduce excessive back pressure and torque caused by cold material feed.

Running temperatures:

Extruder: feed section 285°C, transition 280°C, metering zone 275°C

Head: 250°C, die 230°c

These temperatures are serving as a guideline depending upon the material they might be raised or lowered.

Extruding a parison:

The PC parison is not so elastic as other thermoplastics. Therefore, only relatively short parts can be made by continuous extrusion (appr. 160 to 180 millimeter long). For longer parts, a parison ejected by an accumulator head would permit rapid ejection and avoid alongation. The blow-up ratio is appr. 4 : 1.

Cycle time:

Polycarbonate sets up more rapidly as most other poliophenes and permits a shorter cycle time.

Shut down: The extruder hopper and the srew must be run completely empty. The temperature should be dropped to appr. 150°C. The equipment must be purged with christal-clear polystyrine (PS). However, for complete assurance that all polycarbonate is removed the equipment should be dis-assembled and thoroughly cleaned.

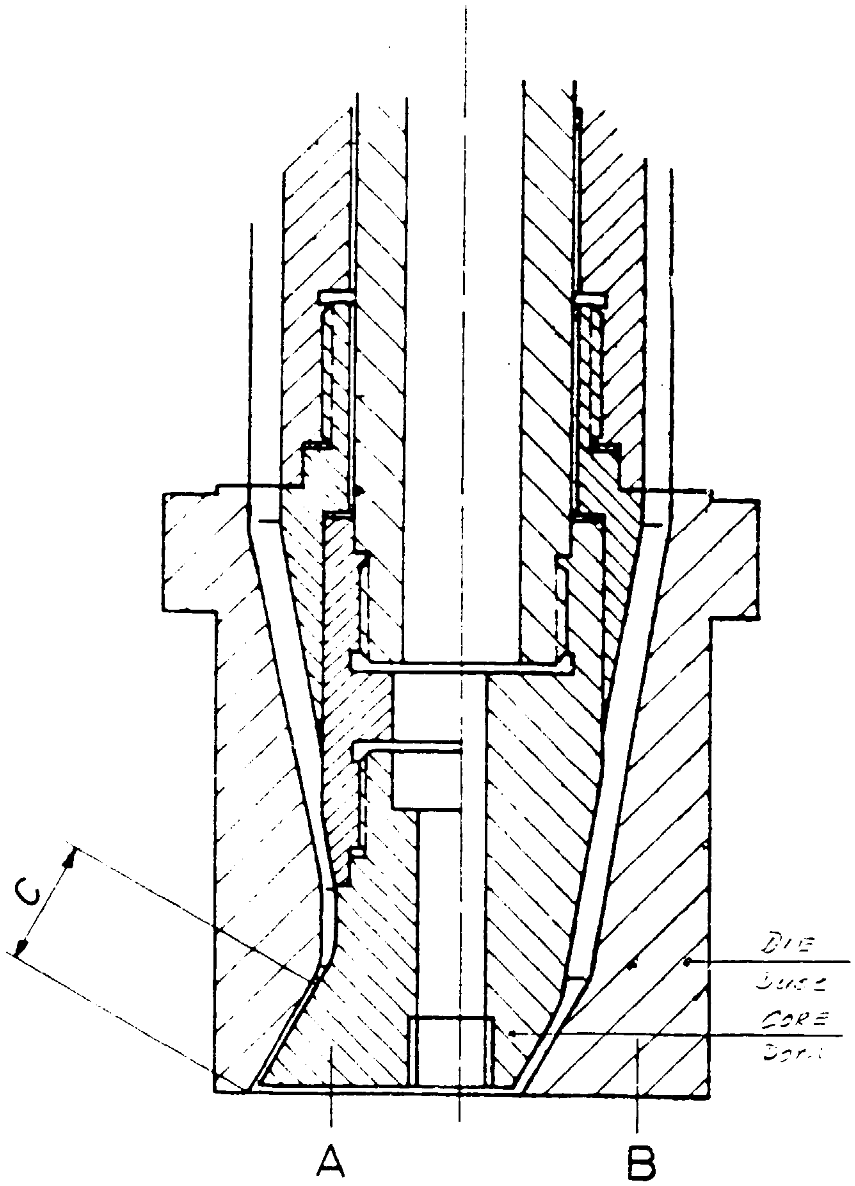
BLOWING TECHNIQUE

Phenomena, which can appear on a blow moulded part

● = primary measures

○ = secondary measures

REMEDY / PROBLEMS	article is not blown	bad neck calibration	neck thread is not formed	neck flash is not separated	article slides off blow pin tear	bottom-handle flash is not separated	bottom-handle area not properly welded	surface markings	surface indents	weak spots in mould parting line	uneven distribution on circumference	uneven wallthickness longitudinaly	edges and corners too thin	article bottom too thin	article too light	article too heavy	holes in article	engraving does not show	article is bulky	welding seams is off-centre	parison is squeezed off-centre	parison falls into the mould
adjust preblow air (more/less)	○	●	○	○				○					○	○			○			○		●
adjust cutter (sooner/later)		●		○																		●
blow pin down (sooner/faster)		●		○																		●
blow pin down (later/slower)		○	○																			○
blow air start (sooner)		●																				●
blow air start (later)		○																				○
increase blow pressure	●		●					○														
decrease blow pressure																						
increase blowing-(cooling)-time	●	○							●										●			
mould closing delay (sooner/slower)	●						●										●					●
increase open-(vent)-time					●														●			
rework mould cutting edges	○					○	○															○
increase mould free milling						○	○			○												
increase mould clamp pressure				○		●				●												
decrease blow pin calibration diamete		○																				
increase blow pin calibration diameter		○	●	○	○																	
re-sharpen blow pin cutting sleeve		○		●		○																
adjust blow pin to mould		●	○	●																		
increase calibration pressure		●		●																		
vent mould cavity	●		●					●		●	●		○					●				
adjust head towards mould	○	○	○								●		○							●	●	
ovalize die tooling											○		●	○								
increase mould cooling						○	○		●										●			
decrease mould cooling							○	●										●				
use parison programmer		●		●	●	○			○			●	●	●	●	●			●			
refer to extrusion table position no.	3, 4, 5, 8										8	7	4, 8	4	6	5	16	10		19	19	



A= Diverging parison tool
B= Converging parison tool
C= Land length
A= konisches Außen - Düsenwerkzeug
B= konisches Innen - Düsenwerkzeug
C= Schlupflänge

Programmeble parison tools

Werkzeuganordnung für Spaltverstellung

BLOWING TECHNIQUE

Phenomena, which can appear on an extruder parison

● primary measures

○ secondary measures

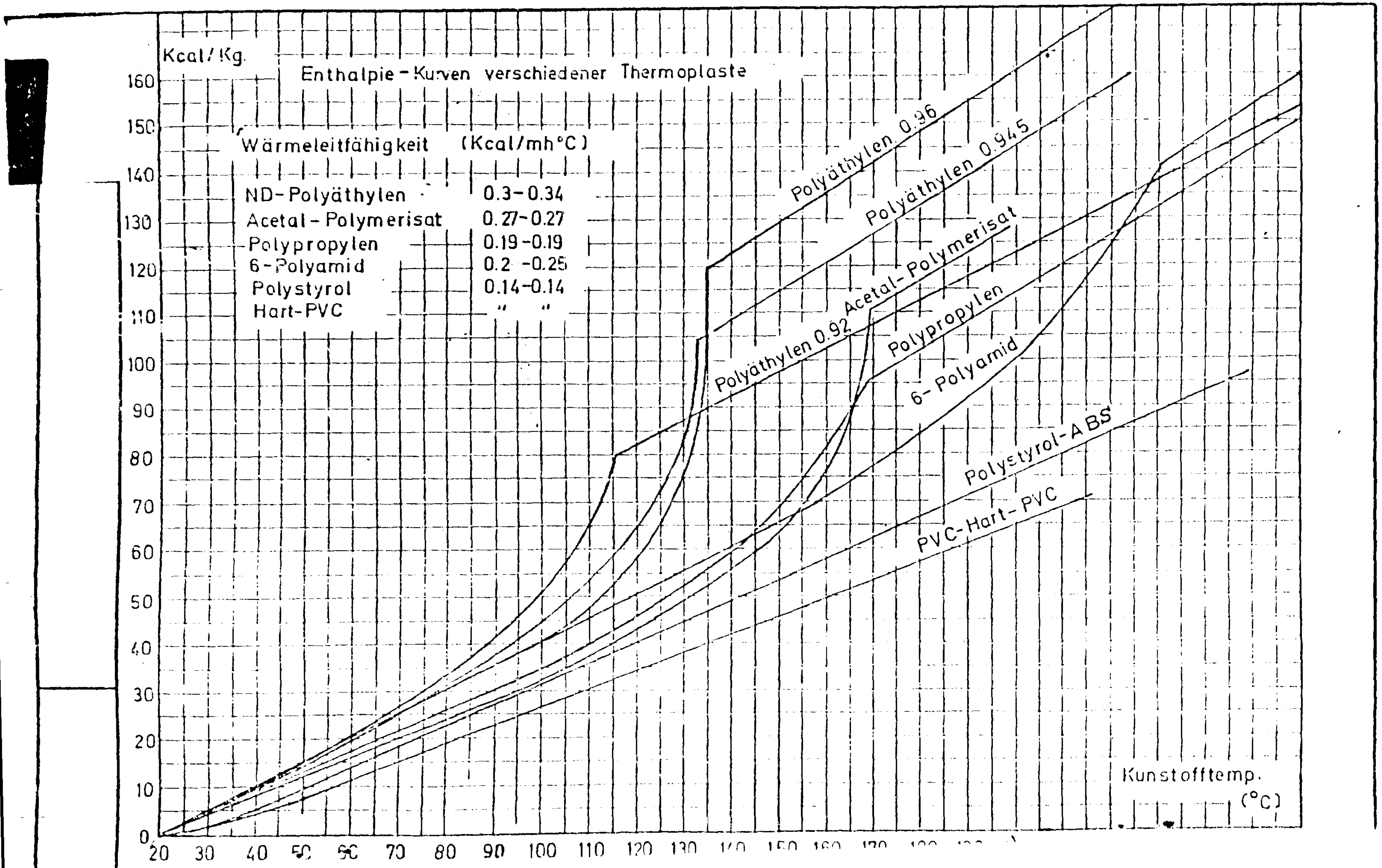
PROBLEMS

1. parison too long
2. parison too short
3. parison diameter too large
4. parison diameter too small
5. parison wall too thick
6. parison wall too thin
7. parison wall varies longitudinaly
8. parison wall varies on the circumference
9. dull inner surface
10. dull outer surface
11. material is not homogenized
12. longitudinal stripes
13. melt fracture
14. cloud appearance
15. spots and burned particles
16. bubbles in extruder parison
17. parison sagging
18. parison length variations
19. parison varies sideways

REMEDY			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
screw speed		faster		●							○		○			○					
		slower	●										○		○			●	○		●
extruder temperature	zone 1	decrease	○			●		○									●		●	●	
		increase		○	●		○						●		●			○			
extruder temperature	zone 2	decrease	○			●		○									●		●		
		increase		○	●		○						●		●	○					
extruder temperature	zone 3	decrease	○			●		○									●	○	●		
		increase		○	●		○						●		●	●					
parison-head temperature		decrease	○			●		○									●		●		
		increase		○	●		○					○	○	○	●						
die temperature		decrease				●		○		○						●	○				
		increase			●		○				●	●	○	●							
adjust parison tooling										●											○
check heater bands			●	●								○		○			●		○		
check thermo couples			○	○								○		○			●		○		
use parison programming			○	○	○	○	●	●	●	●					●					○	○
die-diameter		decrease			●		○														
		increase				○		○													
core-diameter		decrease			○			○													
		increase				○	○														
clean screw									○											○	
clean parison head									○					○				○		○	
clean parison tooling											○	○		●			○				
dry material																		●			
change material													○			○		○			
change regrind portion									●				○			○		○		○	
deflact static electricity																					●
screw cooling																	●		○		
cool hopper area									●											●	

SUGGESTED TEMPERATURE SETTINGS

Polymer	Extruder-Zones Feed-Transition-Metering			Head-Zones Body	Die
PVC Rigid	160 165	165 175	170 185	165 180	160 190
PVC Soft	150	165	170	140	135
PS Polystyrene	170	180	195	180	180
HDPE	185	190	195	200	190
LDPE	150	160	170	160	160
PP	200	195	190	185	170
PC	285	280	275	250	230



Kcal/Kg.
Enthalpie-Kurven verschiedener Thermoplaste
Wärmeleitfähigkeit (Kcal/mh°C)
ND-Polyäthylen 0.3-0.34
Acetal-Polymerisat 0.27-0.27
Polypropylen 0.19-0.19
6-Polyamid 0.2 -0.25
Polystyrol 0.14-0.14
Hart-PVC " "
Polyäthylen 0.96
Polyäthylen 0.945
Acetal-Polymerisat
Polyäthylen 0.92
Polypropylen
6-Polyamid
Polystyrol-ABS
PVC-Hart-PVC
Kunstofftemp. (°C)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170