Small-Scale Sunflower Oil Expelling Technology

Dr. Lourens du PLESSIS,
CSIR, Pretoria, RSA

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1. Small-scale expelling

Oil expellers with the capacity 50 to 300 kg seed per hour are regarded as small-scale. These are the typical on-farm and non-industrial units presently supplied to SMME's.

Typical examples are the Reinartz expeller AP VII (SLIDE). It is a 70 – 100 kg seed per hour, 7.5 kW power unit, manufactured in Germany.

A local manufactured unit is the Destek 300 kg/hour expeller (SLIDE) with 18 kW power requirements. The same company also manufacture a 50-kg/h expeller with 2.5 kW power supply. I am also informed that several oil expeller manufacturers are exporting from India and the Simon Rosedowns mini-press is also well known in Southern Africa.

2. Industrial scale expellers

The Rosedowns Mark 3 screw press (SLIDE) is regarded as a medium size industrial press. Operated in its pre-pressing mode, it can handle 50 tons per day and power requirement is 55 kW. Anderson (USA), Krupp (Germany) and French expellers with capacity above 200 tons /day are used by industrial seed crushers.

3. Hand operated presses

The slide (SLIDE) shows examples of ram and bridge presses which require intensive labour. The oil yields are low and rate of expelling slow. These micro-scale units are not part of this discussion and only mentioned because the users are sometimes very skilled in the pretreatment of seed to attain maximum oil recovery.

4. Sunflower seed composition

The typical composition of high-oil sunflower seed will be discussed and used as example (SLIDE). Seed consists of 25% hull and 75% kernel. The hull and kernel differ in composition and therefore in value. Small percentages of protein and oil in the hull are overshadowed by 50% crude fibre. Kernels on the

other hand contain more than 50% oil and up to 25% protein. It must be emphasized that seed composition can vary and that the hull and kernel composition given above can be different.

A micro section of an oilseed kernel is shown to give the reader a picture of the location of the nutrients. A strong cell wall encloses cell contents. Protein bodies are indicated by "P" and the oil droplets are the smaller bodies around the other cell components (SLIDE).

Sunflower seed contains strong fibre bundles, mainly present in the hull. Some fibre is also present in the kernel fraction.

5. Seed pre-treatment

5.1 Industrial Scale

Sunflower seed is dehulled by the local seed processing factories. The dehulling of seed by impact dehullers, followed by hull separators are not discussed in this presentation. Slide (SLIDE) shows the Bühler dehuller and some of the separation equipment normally applied.

5.2 Small-scale technology

The microscopic picture of the oilseed was included to give the reader the idea of the requirements to get the cell structure broken, to rupture the oil cells to release the oil and to get the liquid oil out of the solid cake. Two physical methods are normally used – mechanical forces and thermal tension.

For comparison the typical industrial seed processing steps are shown (SLIDE). Small-scale oil expelling factories will have to do the seed cleaning step. Dehulling is optional and the following SLIDE presents the different options:

5.3 Dehulling equipment

Impact type dehulling was studied in detail at the CSIR Food Division. The initial design of the disc and blades are shown in the SLIDE. The disc with blades is rotated at a speed that accelerates the seed in the channel towards the outside of the disc to impact onto the ring. The next SLIDE shows the movement of the seed from the inside of the rotating disc to the outside where the impact takes place. It is essential to have two adjustable parameters:

(i) the feeding rate of the seed
(ii) the rotation speed of the disc.

CSIR conducted tests on a machine with a horizontally mounted disc (SLIDE). It was experimentally shown that the optimum rotation speed was 3 000 r.p.m. (tests were done between 2 000 and 4 000 r.p.m.)

It was found that the feed tempo between 56 kg/h and 284 kg/h did not affect the hulling efficiency.

Huller rotation speed determines the amounts of fines. The ideal situation is when seed is impacted to produce a kernel plus two hull halves. During high rotation speeds the ratio of fines – consisting of broken hulls and kernels – become unacceptable. It is very difficult to separate the fines into hull-rich and kernel-rich fractions. Unbroken kernels and hull halves are easier to separate.

In another study, CSIR confirmed that different size seed also behave differently during impact dehulling. Six seed size fractions, based on seed thickness, were tested and proved that seed with the thickness, 3.5 to 4.0 mm, the best dehulling was achieved at 2 880 r.p.m.

A locally manufactured dehuller, based on the impact principle, with the necessary hull and kernel separation facility, has been tested (SLIDE). Capacity

is 500 kg/h and therefore suitable for the 300 kg/h oil expeller.

5.4 Economic incentives for dehulling

Feed specifications for monogastric animals specify the following:

Protein content = 40 g/100 g
Crude fibre content = max 16 g/100 g

Sunflower meal, produced by industrial seed crushers can only achieve this composition if about $^{2}/_{3}$ of the hull is removed before pre-pressing.

Typical compositional data are given in the next SLIDE.

In the previous SLIDE (seed dehulling options) the same typical values were given with the exception that the oil was not removed to 2%. Recalculation of these compositional values to a 2% oil value will give a composition resembling that of industrial meal.

The decision to dehull or not is based on the following questions (SLIDE):

(1) Is the user of the oil cake concerned about the fibre level of the oil cake? If yes, what is the price obtained for dehulled and undehulled oil cake?

(2) It is possible that dehulled meats can expel more oil than undehulled seed. In the two examples ($^{2}/_{3}$ or $^{1}/_{2}$ oil expelling) about 17% more oil is obtained from the dehulled material. This is of importance especially if the value of the oil is much higher than that of the oil cake.

(3) Can the manufacturer utilize the hulls? Presently the best application is to produce heat (boiler, etc.)

(4) CSIR studies on the quality of oil obtained from dehulled sunflower kernels, as compared to oil from undehulled seed, showed that better quality oil is obtained from the former.

The small-scale oil producer can verify the different options by comparing mass balance data. It is necessary to determine the oil yield, oil cake yield, and total losses from 100 kg seed. If dehulling is conducted the procedure becomes slightly more complicated.

It also helps to get compositional data on the seed (protein, oil, moisture) and the oil cake (same components, especially residual oil). Protein and oil

values of the hull fraction are useful to measure kernel losses in the hull fraction.

6. Oil expelling equipment

The small-scale expeller works on the same principle as the industrial machine. In the next slide (SLIDE) different drawings are used to show the worm shaft that transports the seed. The shaft revolves in a barrel of bars (cage). The bars are spaced 0.1 to 0.35 mm to allow the liquid oil to flow out of the cage while solids are carried along inside the cage. It is important to note that the spacing between the worm shaft (screw) decreases along the barrel. This compensates for the decrease in volume caused by the expulsion of the oil and it also increases the pressure on the solid material. The cake is expelled through a throttle or choke while the oil escapes along the length of the cage.

In practical terms the liquid phase must be separated from the solid phase. Cell walls must be cracked and mechanical force as well as thermal tension are applied. Heat is applied to lower the viscosity of the oil to help with flowing out of the solid phase. It also helps with the adjustment of the moisture level to the most favourable value. Heat can therefore be applied to the seed or meats before entering the expeller. Heat is also generated during expelling as a result of the pressure (can be 1 500 bar). Part of the mechanical

energy is transformed into heat. Industrial expellers can cause the temperature to rise above 100°C. Studies on small-scale units showed that seed kept at 40°C will result in a press temperature of 55-60°C. Oil flows effectively above 50°C. In another study the authors showed that while the cake temperatures can reach 70 to 120°C, the oil's temperature remains at 50 to 60°C. The explanation is that most of the oil is expelled in the middle part of the press cage before the frictionally generated temperature rises very much. (SLIDE)

Industrial expellers are also designed with a multistage milling and pressing operation. A press such as the Krupp VPEX unit can be used with unmilled seed where certain sections of the press achieve milling / shearing and the later sections the pressing and oil expelling. (SLIDE)

Other parameters such as feeding rate and choke settings are supplied by the manufacturer and must be verified experimentally.

7. Oil treatment

Crude expeller oil normally contains fines which darken the oil and also interferes with filtration. Some of the small-scale manufacturers pump the hot crude oil into storage tanks, leave it for at least 24 hours before the clear oil is decanted or pumped from the top to the foots (fines and gums) at the bottom of the tank. The

clear oil is filtered through plate and frame units. (SLIDE)

Metal prefilters can also be used to remove the fines continuously. A final filtration can then be applied. (SLIDE)

8. Oil composition

Sunflower oil expelled by mechanical means contains a variety of minor components. The unrefined (or crude) oil can be refined by a number of purification steps to remove the unwanted minor components. The following slide (SLIDE) presents typical values for unwanted minor components at various purification levels.

Phospholipids or gums are unwanted because it separates from the oil during storage. It is removed by degumming before further refining is undertaken. Note that the mechanically expelled oil and the solvent extracted oils contain different phospholipid levels.

The two important quality parameters, peroxide and free fatty acid values, are taken from the *Codex Alimentarius* guidelines. (SLIDE) The unrefined values represent the "cold pressed" or "virgin oils".

Typical free fatty acid values of small-scale-produced sunflower seed oil are 0.2 to 0.8%. It seldom

exceeds 1% and if it does the oil was most probably expelled from low grade seed.

One quality parameter that causes serious problems in the use of unrefined sunflower oil is the flavour and taste. The next slide (SLIDE) lists typical characteristics of unrefined and deodorised sunflower oil. Our experience has been that some unrefined oils had such strong terpene flavour and taste that it was not accepted by the users. Some of the small-scale oil producers claimed that certain seed cultivars were better than the others. This aspect has not been properly investigated and the cause of the strong off-flavour is not yet solved.

The CSIR report on the quality of oils sampled at 10 small-scale factories revealed that the general oil stability as measured by the Rancimat stability test varied a lot (SLIDE). It is interesting to note that if the oxidative stability of the oils is ranked from best to worst, the Peroxide value showed a good inverse relationship with the oxidative stability. (SLIDE)

The producers of unrefined oils are strongly advised to submit their oils from time to time for determination of the three mentioned quality parameters. This will confirm their oil's quality and will also be of value in cases where a dispute on quality arises.

Waxes remaining in the unrefined oils were another concern to the small-scale manufacturer. (SLIDE) The slide shows typical values for unrefined and winterised oils.

9. Oil cake composition

Most of the small-scale factories expel undehulled seed. The previous slide (SLIDE) shows the example of ½ of the oil expelled. This means that 100 kg seed yields 20 kg oil and the remaining oil cake therefore contains 25% oil. Another example is if $^{2}/_{3}$ of the oil is expelled. 100 kg seed then yields 26.5 kg oil and the cake retains 18% oil.

In the case of the 10 small-scale factories the oil remaining in the cake varied between 12.7 and 26.8% (mean value 18.9%). This confirms that on average $^{2}/_{3}$ of the available oil has been recovered. The average seed oil value was 40.0%.

If seed dehulling is considered the oil yield, oil cake composition and total mass balance are completely changed. As mentioned in paragraph 5.4, the economic incentives are listed and discussed.

10. Economical aspects

10.1 The following product prices are accepted for the purpose of calculations of value addition:

Seed price per ton: R2 800.00
Oil price per ton: R7 400.00
Oil cake per ton: R1 500.00 low protein/high fibre

One ton unhulled seed will yield 265 kg oil (value R1 960.00) and 735 kg oil cake (value R1 102.00) if 2/3 oil is expelled. The total value, R3 062.00, is therefore R262.00 above the seed cost.

One ton seed will produce 833 kg dehulled seed. This will yield 258 kg oil (value R1 909.00) and 575 kg oil cake (value R863.00). Total value R2 773.00, resulting in a loss of R27.00 per ton.

If the oilcake buyer is prepared to pay a premium for higher protein oil cake the calculated values will be as follows:

Oil value = R1 909.00
Oil cake value = R1 323.00

Total value = R3 232.00

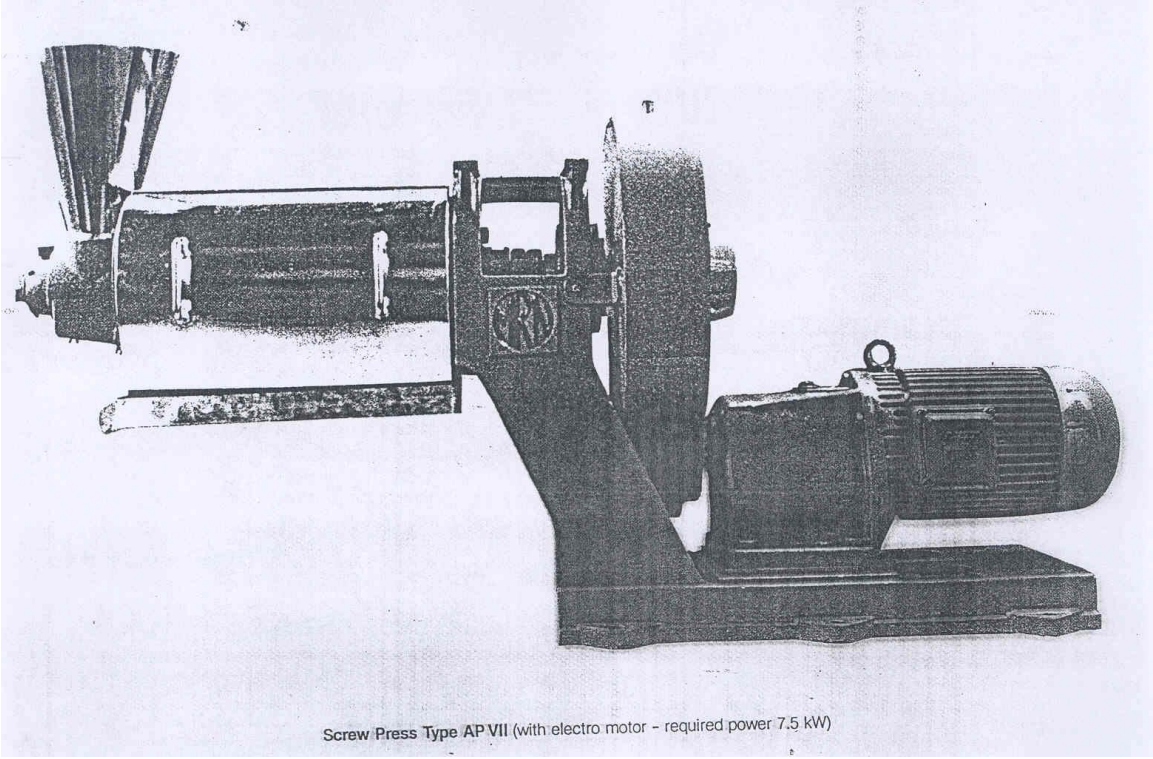
This relates to R432.00 value addition.

10.2 Oil expelling equipment

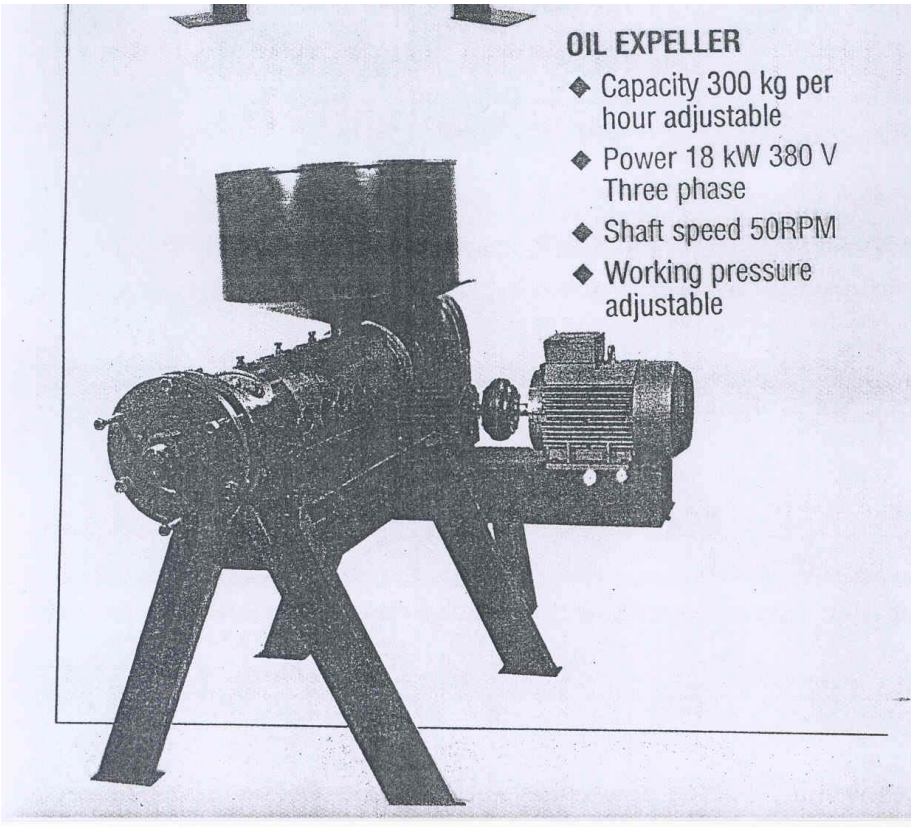
The German 400 kg/h expellers will cost about R350 000.00 and a locally manufactured 300 kg/h machine will cost about R110 000.00. Other equipment such as seed cleaning, weighing, dehulling, hull separators, oil filtration, oil storage tanks, bottling equipment, oil cake milling and storage, etc. will cost at least R1.2 million. This does not include the building and normal services.

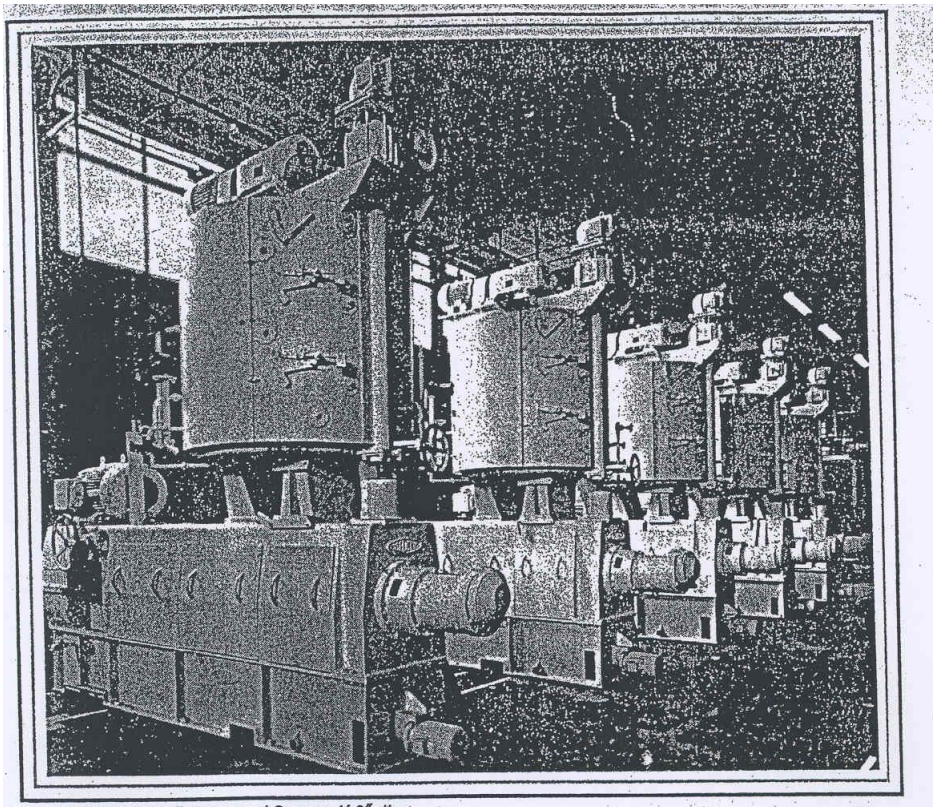
L M du Plessis
Bio/Chemtek, CSIR
December 2001

Appendix A



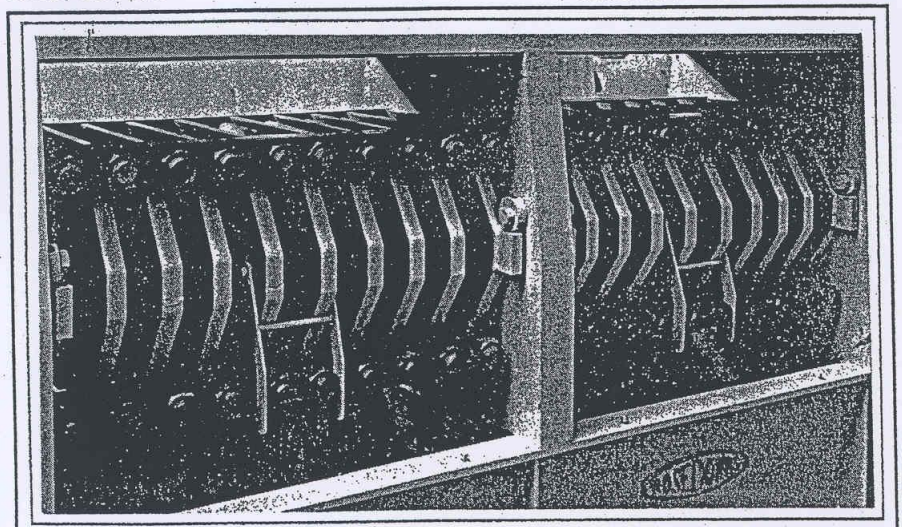
Screw Press Type AP VII (with electro motor - required power 7.5 kW)


OIL EXPELLER
Capacity 300 kg per hour adjustable
Power 18 kW 380 V Three phase
Shaft speed 50RPM
Working pressure adjustable

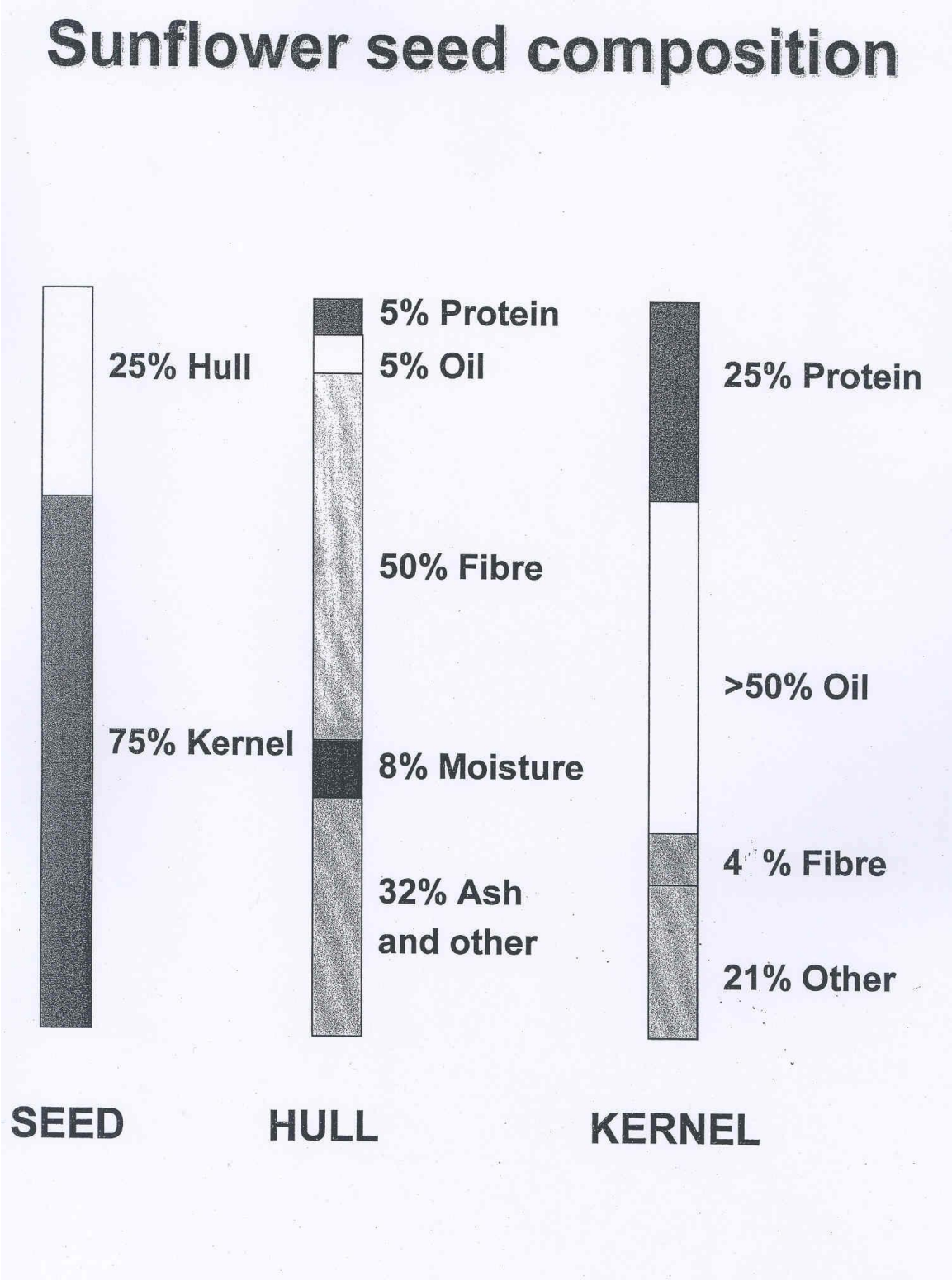


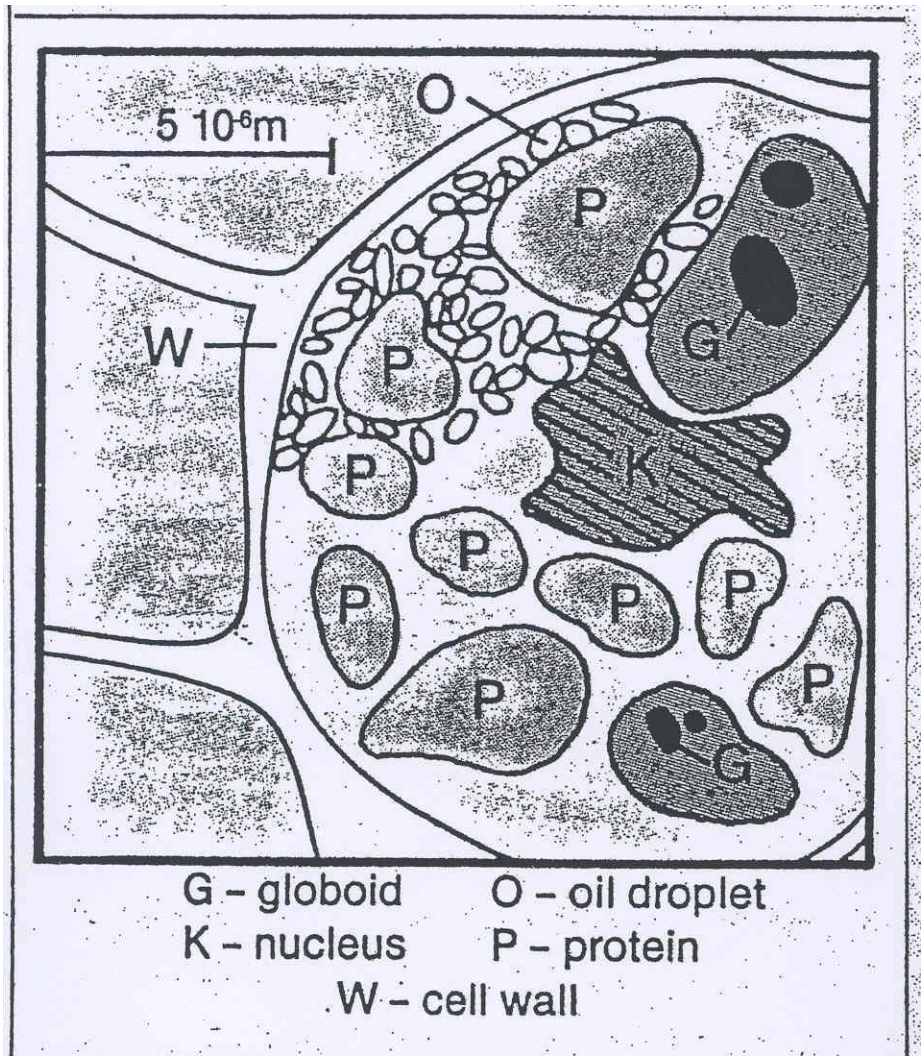
Five Mark 3 Screw Presses and 3 stage 4′ 3″ dia. Stack Cookers processing cocoa beans at Cadbury Bros., U.K.

View of Screw Press main cage section.

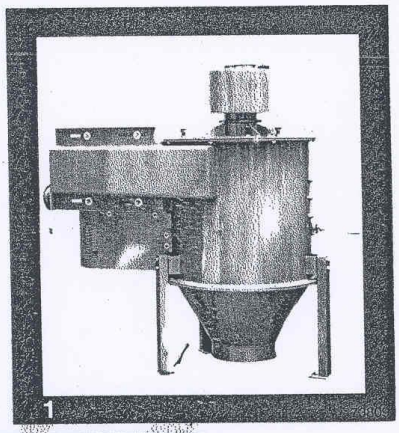


Cooker Size	Approx. Weight tons	Main Motor	Aspiration Fan Motor	lbs/hr steam at 150 psig.	Kg/hr steam at 10 atmospheres.
3 stage 4′3″ (1.3m) dia.	2.2	7½hp (5.5kw)	1½hp (1kw)	120–150	55– 70
4 stage 4′3″ (1.3m) dia.	3	10 hp (7.5kw)	1½hp (1kw)	160–200	70– 90
4 stage 5′6″ (1.68m) dia.	5	15hp (11kw)	1½hp (1kw)	280–350	130–160
5 stage 5′6″ (1.68m) dia.	6.2	20hp (15kw)	1½hp (1kw)	340–425	155–190


Sunflower seed composition
25% Hull
75% Kernel
5% Protein
5% Oil
50% Fibre
8% Moisture
32% Ash
and other
25% Protein
>50% Oil
4 % Fibre
21% Other
SEED
HULL
KERNEL



Microsection of rapeseed



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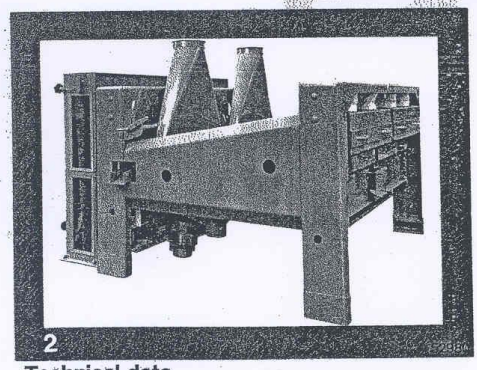


2

Hulling

In order to obtain high-protein extraction meals, the seed must be hulled. We design and build hulling systems based on the head-end process for soybeans and sunflower seeds, and on the tail-end process for extraction meals.

1 DOSB Sunflower Seed Huller

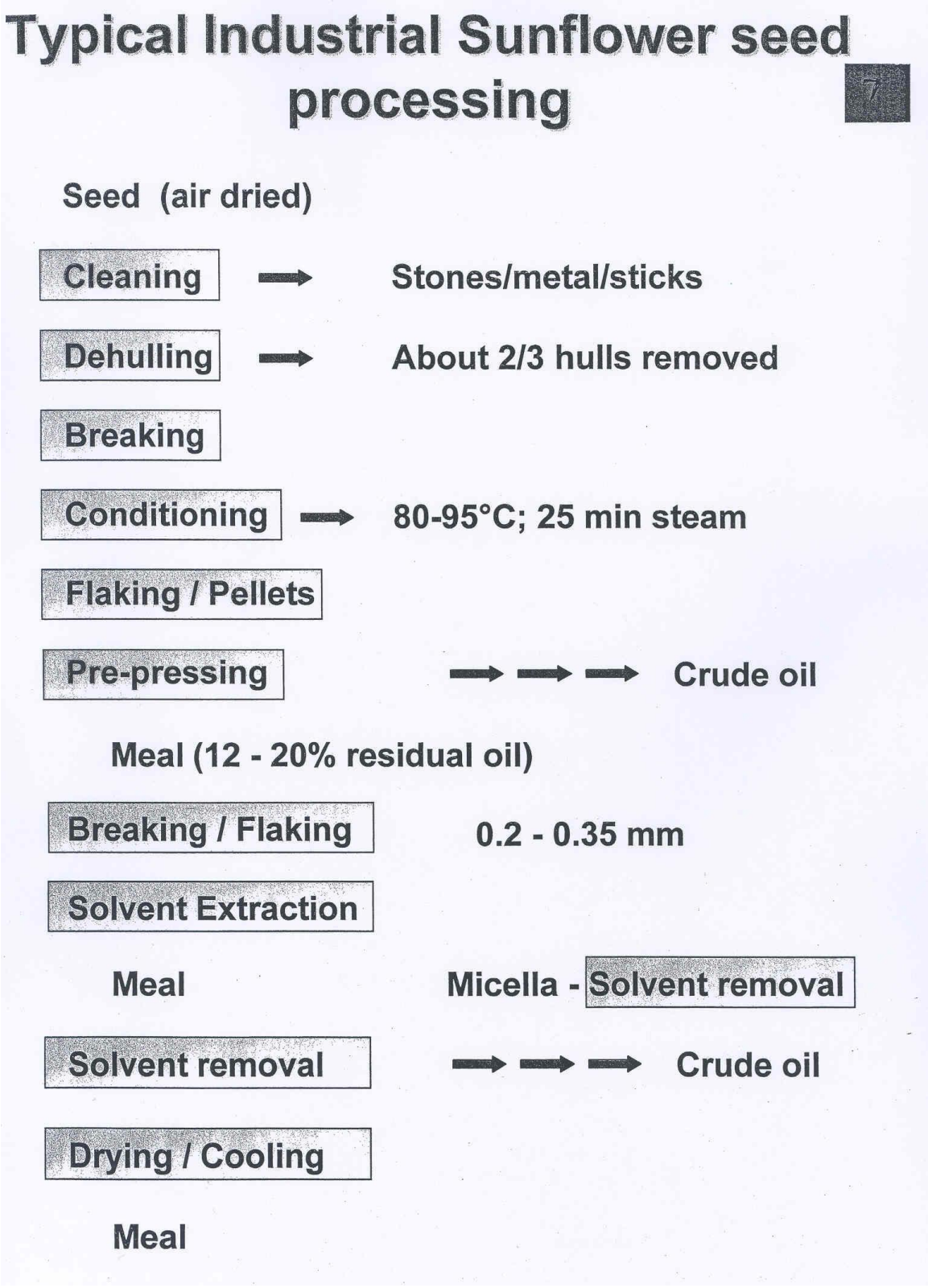
Hulling of the seeds by means of a rotor equipped with beaters. Optimum feed is ensured by incorporated feeder. The required efficiency can be achieved by adjusting the impact ring.

2 MTMA-15150 DS Hull Separator

For the processing of soybeans and sunflower seeds and for the separation of the detached hulls from the kernels in head-end hulling systems. Double-deck screens with rubber ball cleaners. Rotary screen movement. Aspiration nozzle on the upper screen deck. Attached aspiration channel for hull separation from the middle fraction. This machine can also be applied in tail-end hulling systems.

Technical data

Machine	Types	Drive rating (kW)	Capacity
DOSB Sunflower Seed Huller	1	15	up to 250 t/24 h
MTMA-15150 DS Hull Separator	5	1.1–1.5	up to 400 t/24 h


Typical Industrial Sunflower seed processing
7
Seed (air dried)
Cleaning
Stones/metal/sticks
Dehulling
About 2/3 hulls removed
Breaking
Conditioning
80-95°C; 25 min steam
Flaking / Pellets
Pre-pressing
Crude oil
Meal (12 - 20% residual oil)
Breaking / Flaking
0.2 - 0.35 mm
Solvent Extraction
Meal
Micella - Solvent removal
Solvent removal
Crude oil
Drying / Cooling
Meal

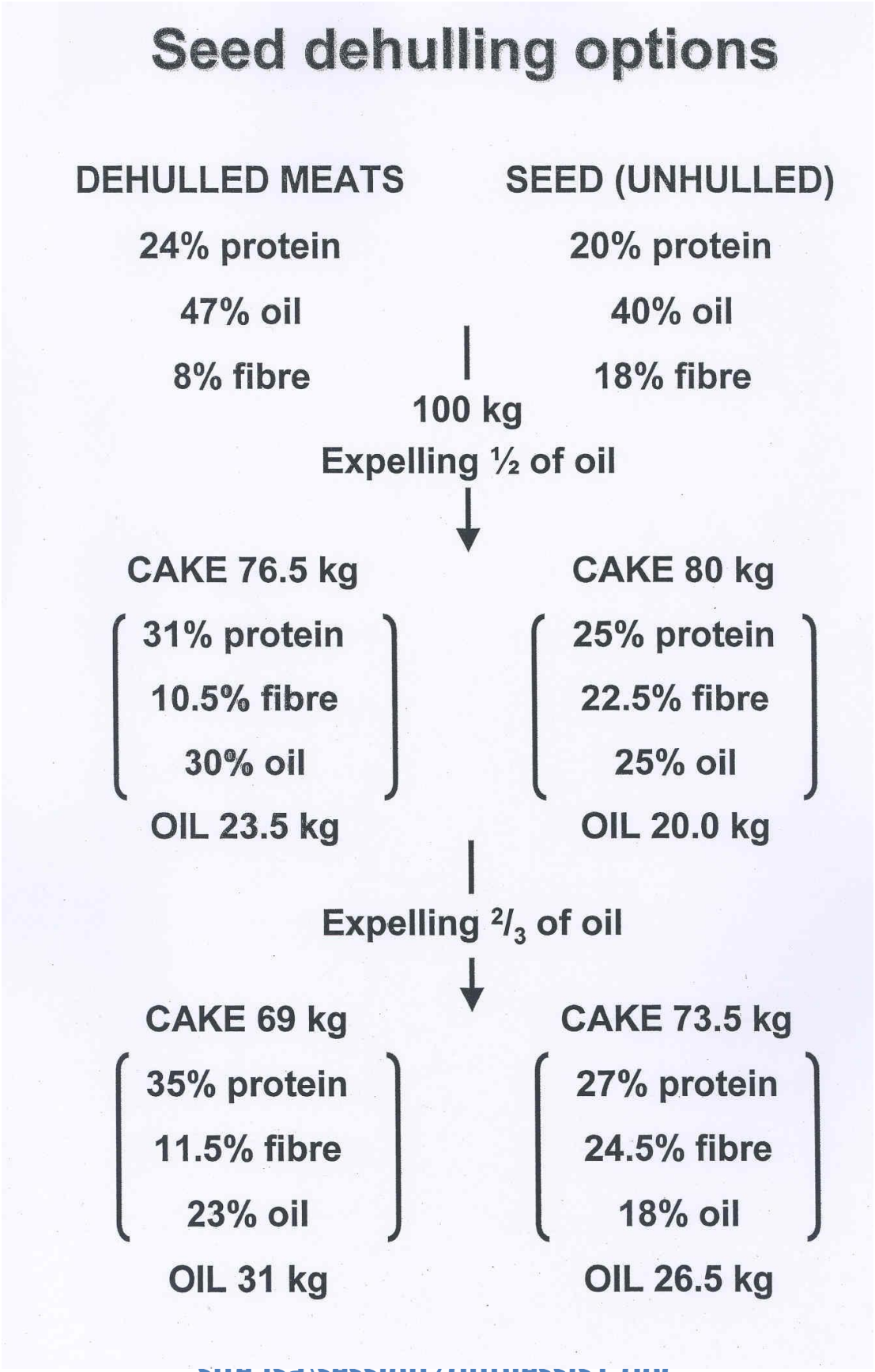

Seed dehulling options
DEHULLED MEATS
24% protein
47% oil
8% fibre
SEED (UNHULLED)
20% protein
40% oil
18% fibre
100 kg
Expelling ½ of oil
CAKE 76.5 kg
31% protein
10.5% fibre
30% oil
OIL 23.5 kg
CAKE 80 kg
25% protein
22.5% fibre
25% oil
OIL 20.0 kg
Expelling 2/3 of oil
CAKE 69 kg
35% protein
11.5% fibre
23% oil
OIL 31 kg
CAKE 73.5 kg
27% protein
24.5% fibre
18% oil
OIL 26.5 kg

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Fig. 1

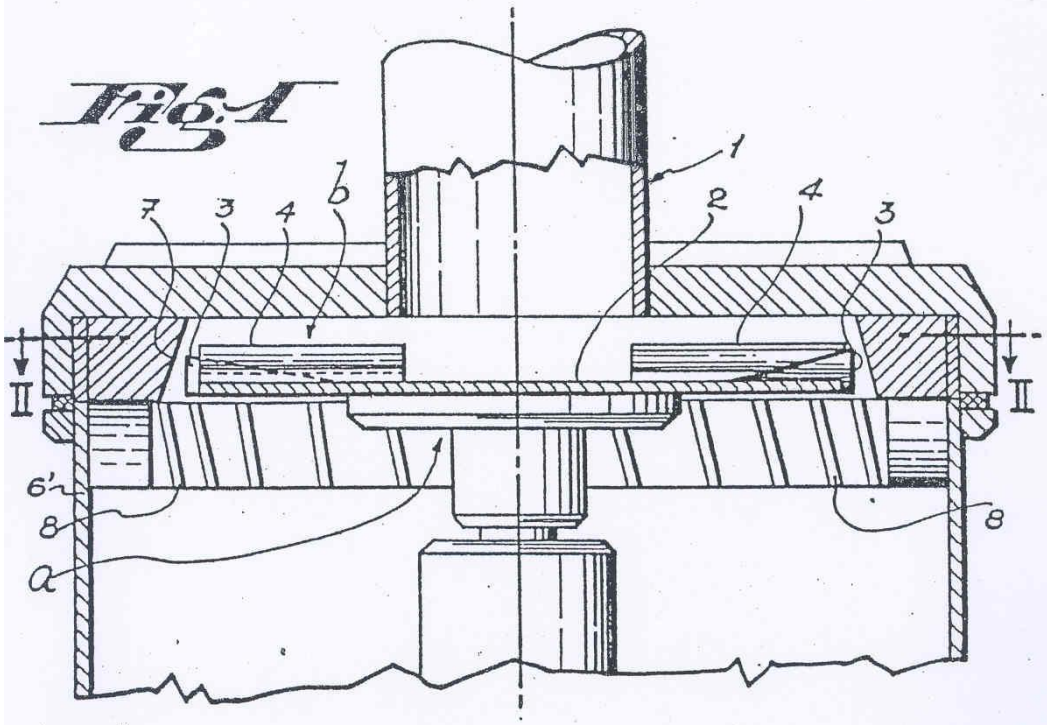
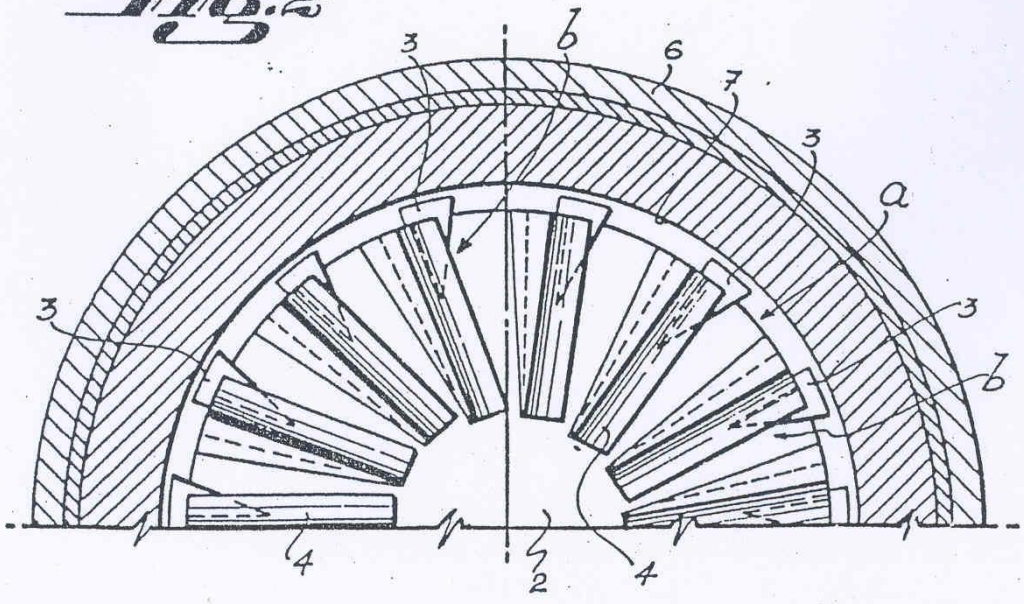


Fig. 2



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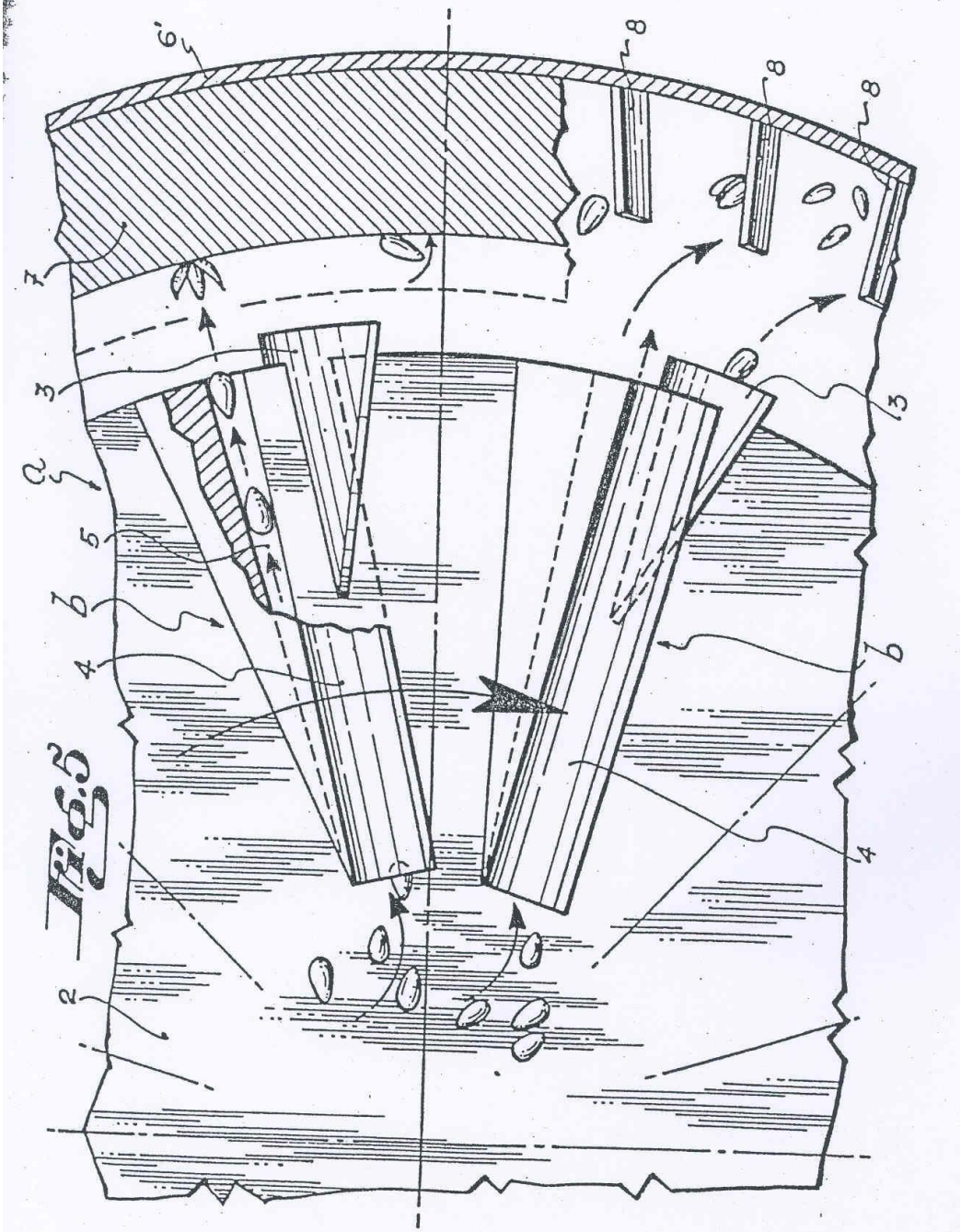

FIG. 2

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Sentrifugale impak-tipe dopper (NVNI) - Loodsaanlegskaal