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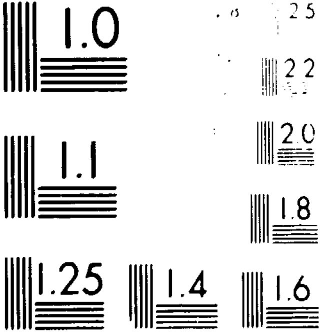
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RAW MILL SYSTEMS

CRITERIA GOVERNING THE CHOICE OF GRINDING MILLS AND DEVELOPMENT TRENDS*

by

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1. <u>Selection criteria</u>

Selecting the correct raw grinding mill is subject to various physical, process-engineering, mechanical and economic parameters.

Since these conditions are never of identical combination and importance, a separate assessment has to be made for any newly set-up plant.

Similar considerations should be made when extending an existing facility, duly taking into account practical experience and weak-point analyses.

We are quoting some of the relevant criteria:

- raw-material properties
  (grindability, moisture, crushing properties, wear rate, feed size)

- waste-gas utilization subject to combined grinding and drying (waste-gas volume and temperatures)

- throughput rate
  (quantity of finished product attained per hour)

- operating costs
  (costs of energy, wear, personnel)

- capital expenditure
- procurement of wear and spare parts
  (to be imported, local manufacturing facilities)
- environmental health requirements
  (dust, noise, vibrations).

The following grinding systems are available:

- air-swept grinding mills
- oversize recycling mills with bucket elevator
- roller mills
- tube mills combined with primary crushing equipment, such as hammer mills, which combination is termed by us, e.g., 'tandem' mills.

We are specifying below various interrelations which may be of assistance when having to choose one of the systems mentioned above.

With respect to 'grindability' of a material, one differentiates between the theoretical specific work index ascertained by the laboratory testing equipment and the specific work index of practical operation.
The experimentally determined specific work index is converted to the fineness required for the raw meal. Moreover, initial moisture, crushing properties, feed size and grinding-mill system used will have to be included in the considerations.
The sum of these individual evaluations yields the actually required work index.

This actually required work index, multiplied by the desired plant throughput, results in the work index to be installed. This value is referred to for ascertaining the mill tube dimensions and for calculating the pertinent parameters of the drive components.

The initial moisture of the raw materials is included in the heat balance, duly considering the selection criterion "waste-gas utilization". Combining specific work index - determined for the raw material - and feed moisture of the raw material results in a potential selection criterion for a specific grinding mill system.

Illustration 1 explains this statement. It represents applications of air -swept grinding facilities and oversize recycling mills with bucket elevator as a function of moisture and grindability.

Apart from the necessary thermal calculations, the relevant main drives and their power requirement have been determined for an air-swept grinding mill and for an oversize recycling mill with bucket elevator. The corresponding components of the air-swept grinding mill are the mill drive and the drive of the circulating air fan.

The relevant parts of the oversize recycling mill with bucket elevator are the mill drive, the drives of the bucket elevator, of the air classifier and of the mill fan. Since this mill system requires the addition of a drying chamber for feed moistures above 5% (however, for air-swept grinding mills from 8% moisture onward only) and in view of the fact of higher pressure losses in case of higher moisture contents because of the resulting higher gas throughput required, two different situations have to be examined for the oversize recycling mill with bucket elevator. The comparison will not include feed moistures above 8% as, in general, an oversize recycling mill with bucket elevator will not be used for this application.

The calculation result can be roughly forecast by the fact that drying raw material of increased moisture requires continuously larger waste-gas volumes which - from a given quantity onward - will be enough for pneumatically handling the circulating material.

Power requirement of bucket elevator and air classifier have to be met in addition which means that an oversize recycling mill with bucket elevator is characterized by higher energy consumption than an air-swept grinding mill.

The area left of the continuous line in illustration 1 is most favourable for an air-swept grinding mill. For the sake of completeness we would like to say that the capital expenditure for an air-swept grinding mill is always less than for an oversize recycling mill with bucket elevator.

Since this diagram has been established on the basis of specific preconditions, such as bucket elevator height, type of air classifier, fan efficiency, etc., a given project will require exact calculations for marginal areas.

The mechanical layout of a plant does not dictate limit values regarding maximum capacity of tube mills. Currently requested maximum capacities can be realized in most cases with regard to mechanical engineering.

However, the construction of large combined grinding and drying facilities is confined with regard to parameters which, at first glance, would not have anticipated such restriction. These are geometry and physical aspects of the mill tube. While power requirement and, consequently, plant throughput increase by the third power, the free mill cross section not covered by grinding media is augmented only by the second power. This statement is outlined by illustration 2.

It can be assumed for any grinding operation that there will be a given minimum and maximum gas velocity.

Subject to a specific gas velocity being maintained in the grinding compartment, the maximum permissible gas throughput is reduced with increasing mill tube diameter. This will automatically lower the maximum permissible initial moisture, too.

2. Development trends

KHD Humboldt Wedag AG consider the basic principle of the 'tandem' grinding facility to be of conventional type which has been applied for producing raw meal in cement plants for more than 15 years (illustration 3).

The development aimed at creating a grinding facility highlighted by reduced energy requirement and capable of handling large waste-gas volumes for drying, while retaining the advantages of an air-swept grinding installation such as simple design at correspondingly low service requirements and easy adaptation to unavoidable fluctuations regarding raw-material properties and operating conditions.

The main feature of the 'tandem' grinding installation is the integrated impact hammer mill meant for primary crushing and pre-drying of the raw material. It differs from conventional impact hammer mills by a solid grinding path lined with strong wear plates instead of a grate; moreover, it has been provided with specific inner assemblies.

(Taken from: "Practical experience gained with the 'tandem' grinding mill for cement raw meal" author: R. Zisselmar; publication being prepared)

The satisfactory results of any 'tandem' grinding facility delivered in the past have been a stimulus for us continuously to improve the basic layout of the system. For example, the impact hammer mill is similar to the "heated hammer crusher with solid bottom", first supplied in 1965, only with regard to its duty. This first machine reached a throughput of approx. 35 t/h at a rotor diameter of 1,250 mm and a rotor width of 1,400 mm.

The impact hammer mill shown in illustration 4 attains throughput rates of 340 t/h at a rotor diameter of 3,000 mm and a rotor width of 3,000 mm and a maximum feed moisture of 15 %.

The inside configuration of the machine has been substantially adapted to the designs typical of impact reduction.

A further novelty is the hammer shown in illustration 5. It is of split design, comprising the head carrier and a quickly replaceable, plug-type hammer head.

During operation, the hammer head is retained exclusively by the effect of centrifugal force. Three hammers of this type have been applied in an impact hammer mill in a German cement plant for 4 years now. While the "old" hammer type reached a service life of approx. 2 years in this plant at comparatively low wear (old hammer shown in left part of illustration 5), the definite lifetime of th [illegible]w" hammer cannot yet be predicted in this plant.

The first impact hammer mill completely equipped with this new hammer type has been operating since February 1981 at a throughput of 250 t/h.

This type of hammer has been dealt with in the paper by Horst Schmidt, Cologne, entitled "Optimizing of reduction tools in impact hammer mills".

Anyone having ever been concerned with girth gear/pinion drives realizes that this component requires special attention. Therefore, it is not surprising that the somewhat more costly central drive is continuously more appreciated.

'Central drives' have always been wishful thinking for grinding-cum-drying equipments, in particular, when coming across increased raw-material moistures. The layout of the 'tandem' grinding installation permits fitting a central drive (illustration 6). Two plants of a capacity of 140 t/h each have started operation without implying any difficulty. The mill tubes used had a diameter of 4.4 m and the installed driving capacity equalled 2,130 kW.

The last novelty introduced for the overall layout of the 'tandem' grinding plant has been a system without classifier, providing instead for direct separation of the finished product in the electrostatic precipitator. Illustration 7 is a schematic diagram of this system.

Most of the waste-gas volume discharged from the preheater/kiln system is directed to the mill fan via the impact hammer mill, the separator and the electrostatic precipitator. The direct line between preheater/kiln system and electrostatic precipitator is closed during direct mill operation. A small portion of the hot gas is routed through the mill tube for secondary drying of the material.

To minimize dependency of the mill system on possible fluctuations during kiln operation, a partial gas flow is recycled to the mill behind the electrostatic precipitator.

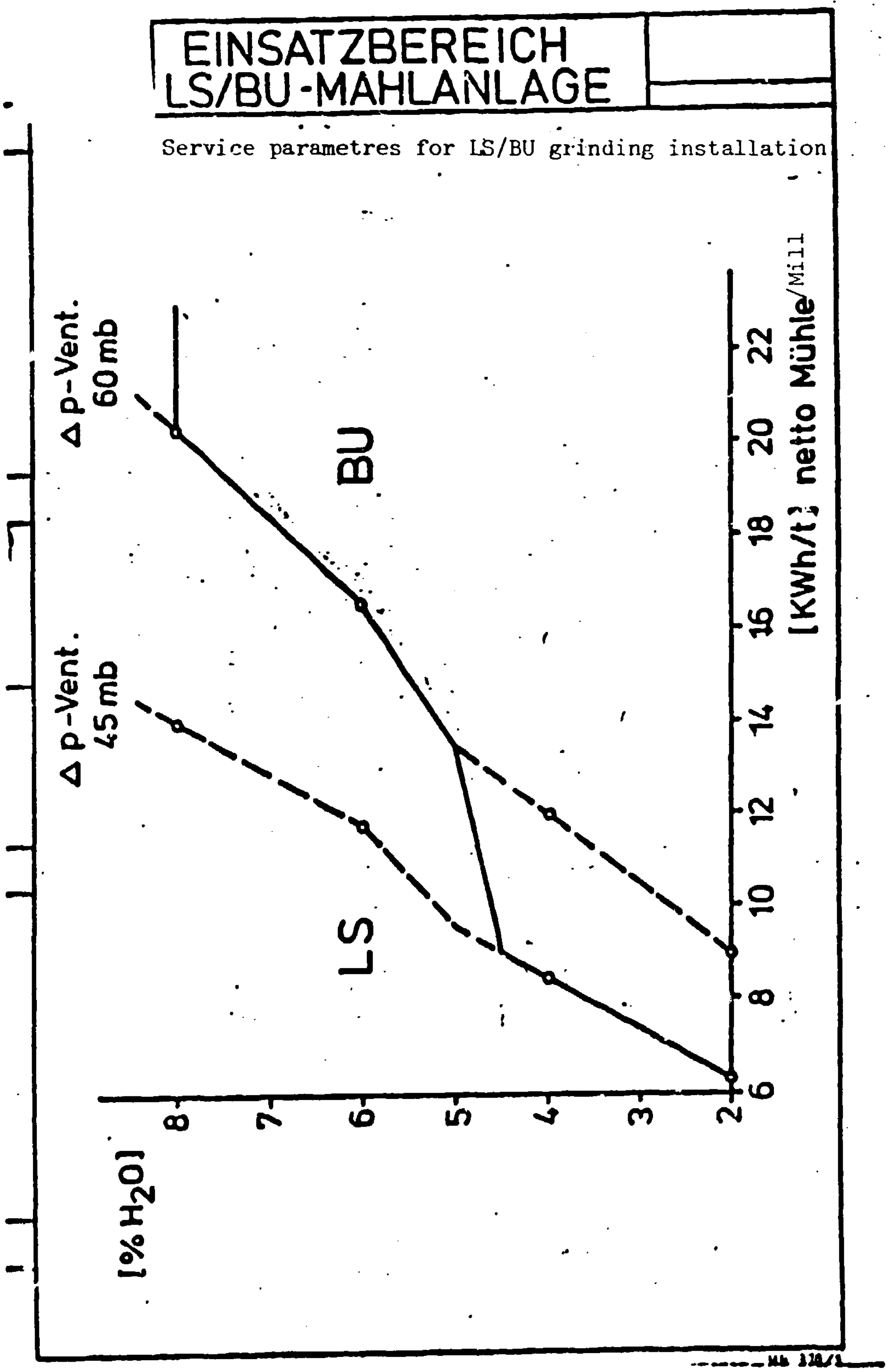
Though implying the well-known drawbacks of direct separation, the system offers the advantage of a significantly less complicated structure.

Start-up of such facility, laid out for a throughput of 250 t/h and installed in a German cement plant did not indicate any disadvantage with respect to process engineering. Since the total pressure losses equal no more than approx. 55 mbar within the grinding mill- and dust-collecting system, the total energy requirement will be less than for conventional 'tandem' grinding plants.

Moreover, the simple plant structure, not including mechanical separator and mill fan - reduces the building volume. The building volumes shown in illustration 8 result for the mill of a tube diameter of 4.6 m set up in the past and with due consideration to 'tandem' grinding mills.

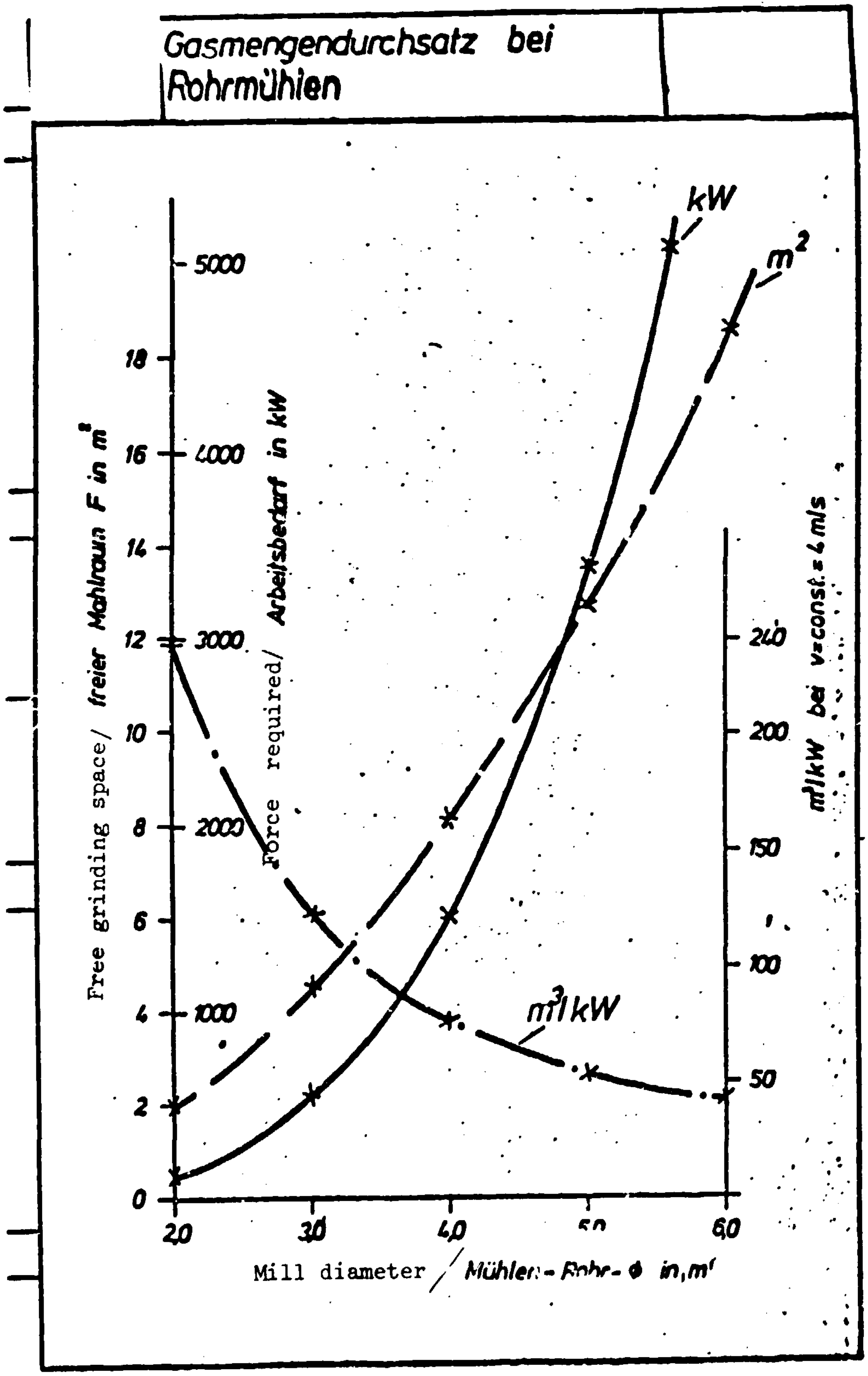
For enabling a comparison with the roller mills being known for requiring particularly small building volumes, we have ascertained the roller mill sizes corresponding to tube mills and the building volumes they require, assuming a given grindability for the feed material.

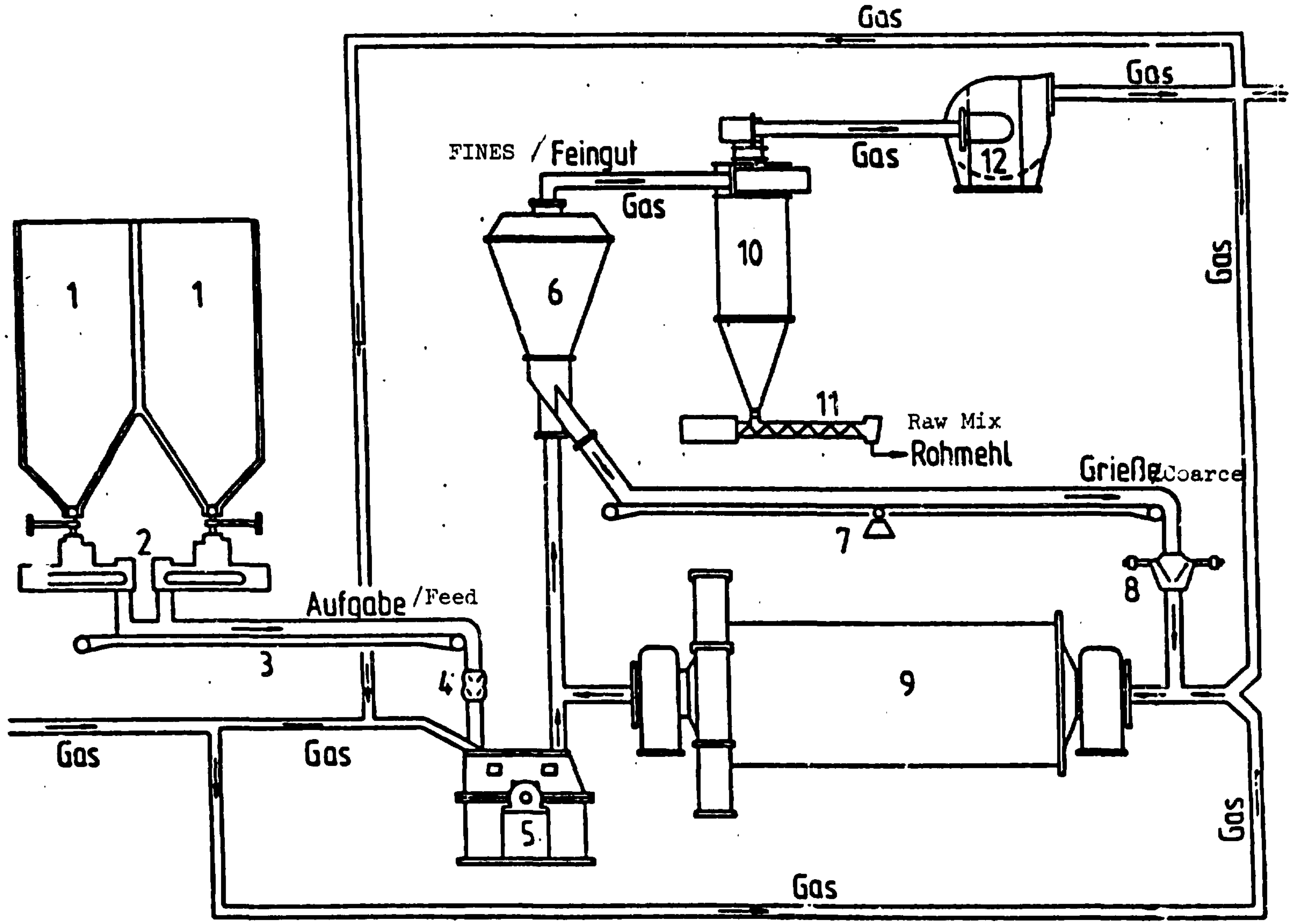
The diagram reveals that the system presented permits reqlizing a mini. cubical content out of all industrially applied grinding mill facilities.


EINSATZBEREICH
LS/BU-MAHLANLAGE
Service parametres for LS/BU grinding installation
Δ p-Vent. 60 mb
Δ p-Vent. 45 mb
BU
LS
[% H_2O]
2 3 4 5 6 7 8
6 8 10 12 14 16 18 20 22
[KWh/t] netto Mühle/Mill

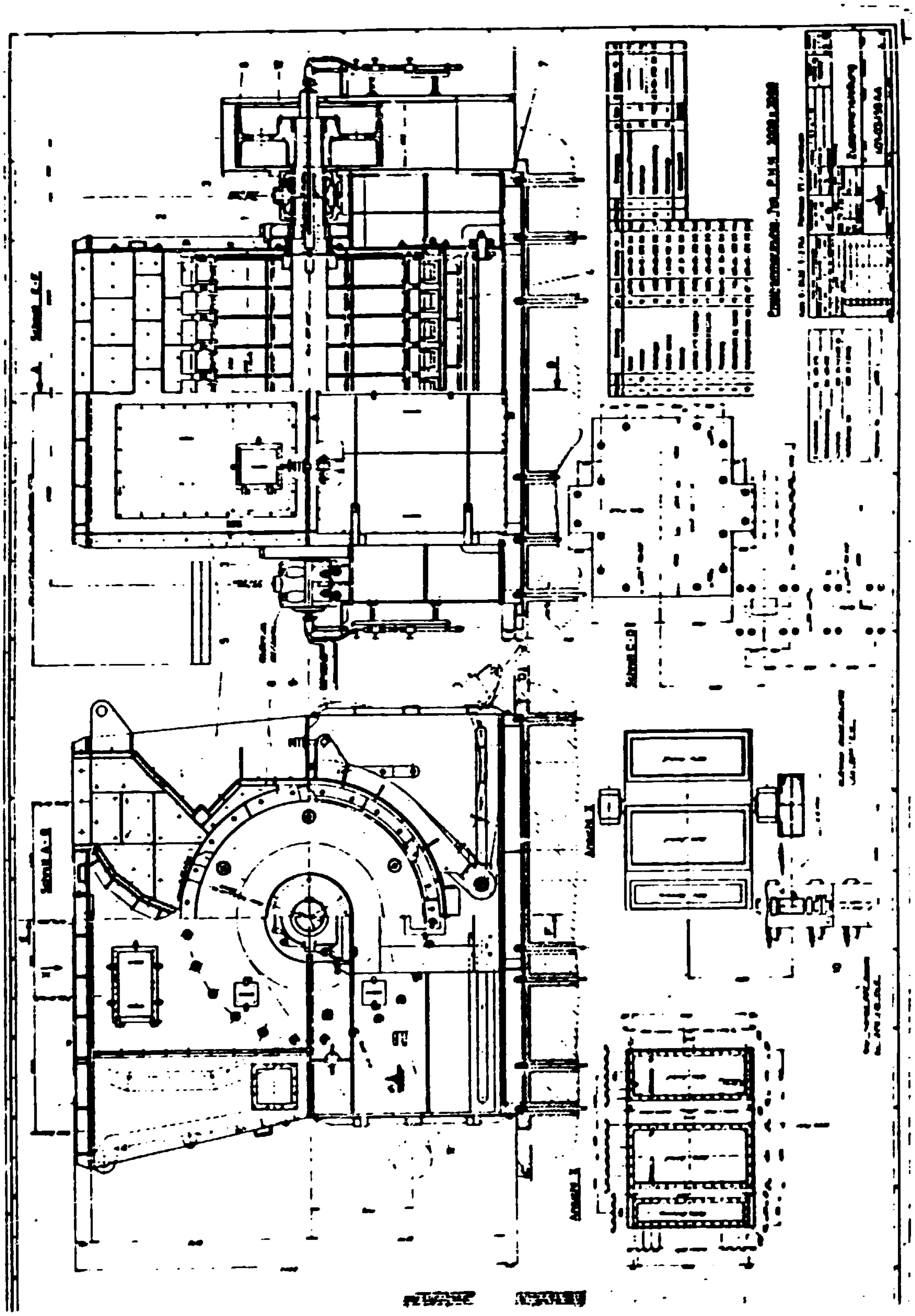
illustr. 1

Ventilation parametres for tube mills.

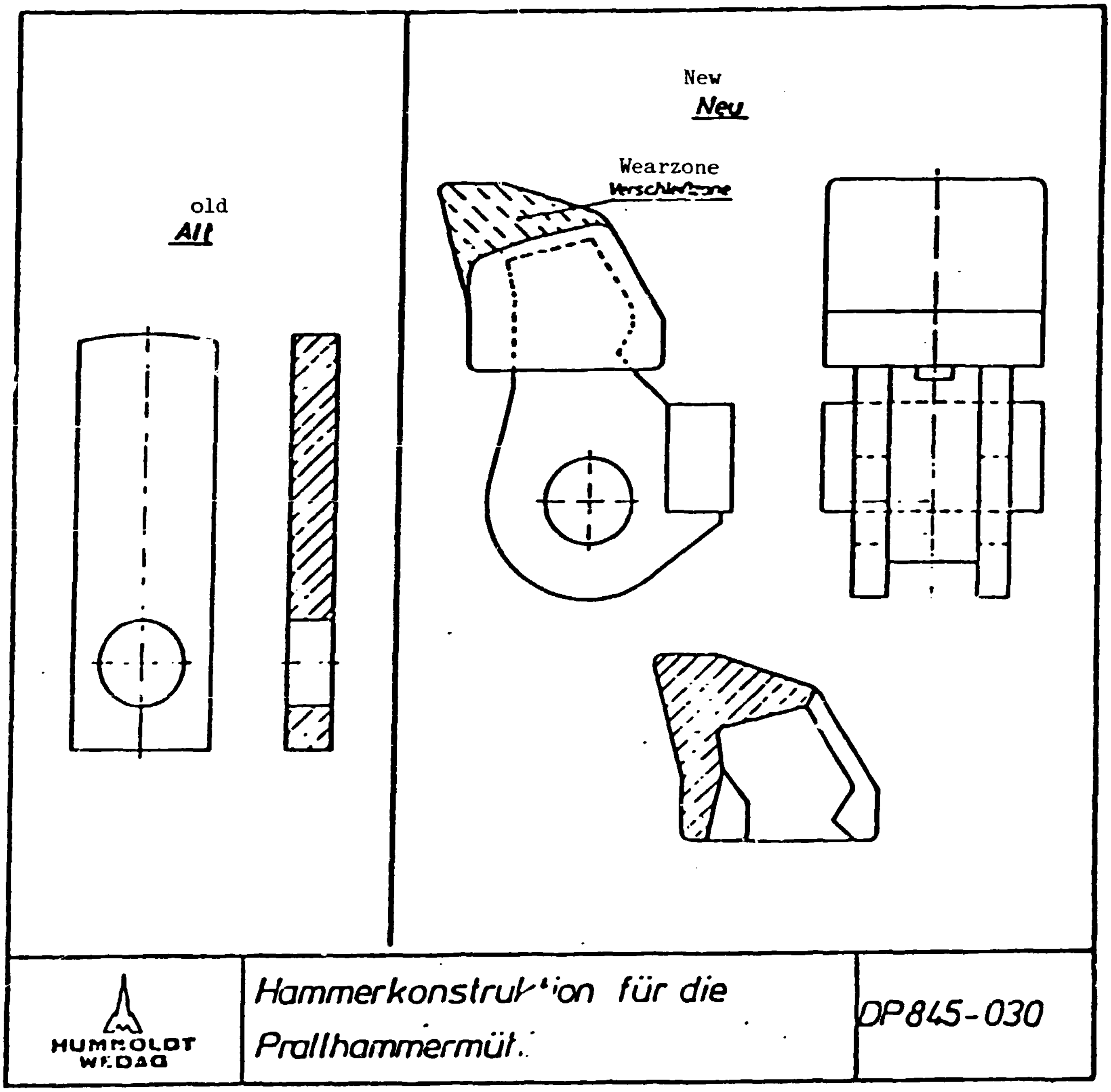



Gas
Gas
FINES / Feingut
Gas
Gas
12
10
1
1
6
Gas
11
Raw Mix
Rohmehl
Grieße/Coarce
2
7
8
Aufgabe /Feed
3
4
9
Gas
Gas
5
Gas
Gas

illustr. 3

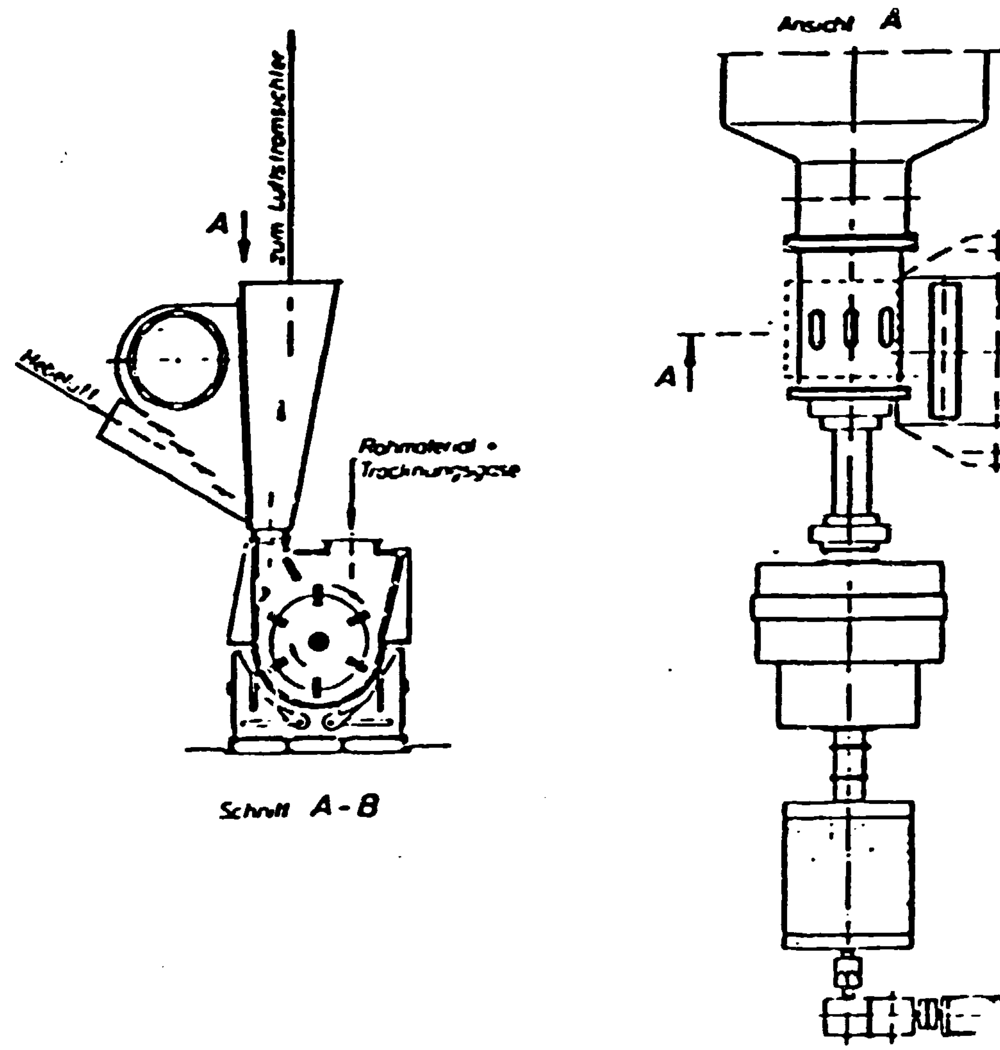


illustr. 4



Design of Hammers for the Impact Mill.

illustr. 5

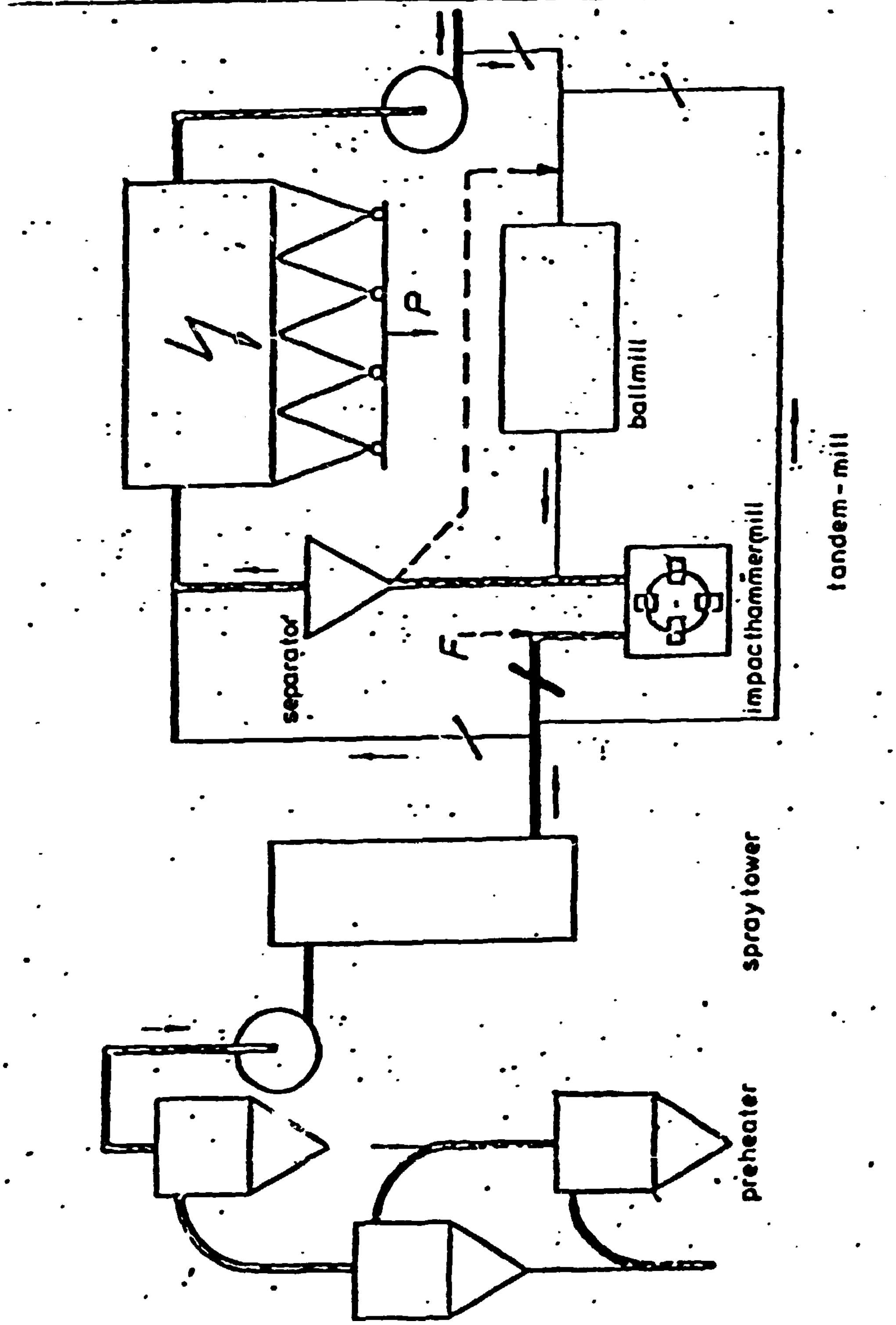


	Zentralantrieb für Tandem - Mahltrocknungs Anlage	DP845-044

Central drive for tandem dryer/crusher mill.

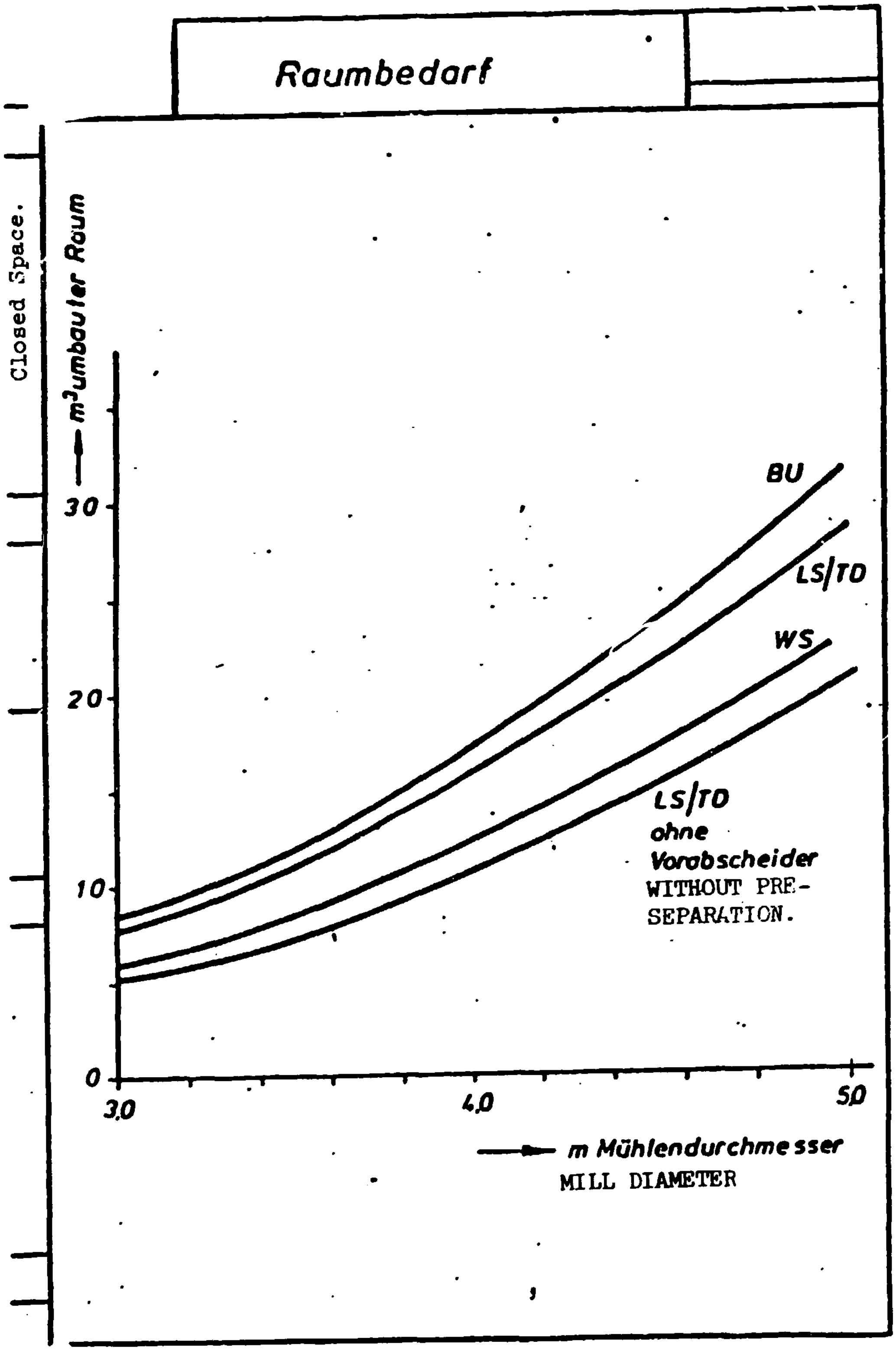
illustr. 6

Waste gas utilisation with direct separation in electrostatic separator



illustr. 7

Grinding Space Requirements.



illustr. 8