

EXPERIENCE WITH ELECTROSTATIC PRECIPITATORS DOWNSTREAM OF SPRAY
ABSORBERS FOR SO₂-SEPARATION

H.J. Heer
N. Seyfert
Apparatebau Rothemühle
Brandt + Kritzler GmbH
D-5963 Wenden
Germany

D.P. Tonn
B. Kronenberger
Babcock & Wilcox
Environmental Equipment Division
Barberton, OH
U.S.A.

Abstract

Electrostatic precipitators behind spray absorbers have been operating for many years and have met most expectations. The calculated desulfurization efficiencies in the range of 90 % have been confirmed and the dust emissions can be limited to values below 0,02 gr/scf (50 mg/Nm³).

Some special operating experiences relating to specific dust characteristics have been reported. Problems with dust caking on the discharge electrodes and on the perforated plates of the gas distribution internals have been addressed.

Corrosion problems, especially on the collecting electrodes, can occur when coals of high chlorine content are fired.

Introduction

Spray absorption for sulfur dioxide (SO_2) separation from furnace flue gas has been successfully applied in both electric power generation and waste incineration plants. In the United States, most installations include fabric filters of the reverse flow design concept. In Europe, most are equipped with either electrostatic precipitators (ESP) or fabric filters of the pulse jet design. The following describes European experience with electrostatic precipitators placed downstream of the SO_2 separation equipment (Figure 1).

Design and Arrangement

In Europe, flue gas desulfurization processes are not chosen merely on their efficiency, capital and operating cost. An important issue is disposal of the resulting reaction product. Calcium sulfite produced by spray absorption is mainly dumped in landfills because of the high cost of treating the material for reuse.

To minimize the high dumping costs, dust collectors for the flyashes in the flue gas are traditionally arranged upstream of the spray absorbers or existing dust collectors are converted for this purpose (Figure 2). The flyashes separated here are used primarily as additives in the cement industry or road construction. Therefore the dust collector, as a component of the spray absorption process, has almost exclusively been used to collect reaction products or unreacted components of the input product (Figure 3).

Absorption Process

Additional SO_2 absorption can take place downstream of the actual spray absorption system in either a fabric filter or an electrostatic precipitator. Numerous publications on this subject suggest that this "secondary reaction" is much greater in the fabric filter than in the electrostatic precipitator. However, past investigations have been on electrostatic precipitators which by today's standards are of a very small design, i.e., with flue gas residence time in the electric field of 5 seconds or less. Today's customary values, however, are in the range of 15 to 25 seconds. This provides a considerable increase of the contact potential between the absorbent and the harmful gas components, i.e. between calcium hydroxide [$\text{Ca}(\text{OH})_2$] and SO_2 .

Due to system design, these contacts between $\text{Ca}(\text{OH})_2$ and SO_2 are less intimate in the electrostatic precipitator than in the fabric filter, because the gas does not pass through an absorbent layer. However, the contact potential during the flow through the ESP should not be underestimated because of the electric wind blending that can repeatedly take place depending on precipitator length and residence time (Figure 4).

This electric wind is a well known phenomenon in ESP technology. The dust separation effect is produced by the ionization of the gas and attachment of the gas ions to the dust particles. Driven by the electric field, the ionized gases migrate towards the collecting electrodes and for reasons of continuity have to migrate back towards the discharge electrodes after releasing their electric charge. Therefore, a cross flow superimposed on the main flow takes place. The velocity of the electric wind depends on the achieved discharge current density and therefore also on, for example, the profile of the discharge wire. It may reach values up to 1.6 ft/s (0.5 m/s) and, assuming a normal gas velocity of about 3.3 ft/s (1 m/s) can be significant.

It is likely that a secondary reaction in the order of 20 % to 50 % takes place. Therefore the overall SO₂ absorption efficiency of 90 % can increase to between 92 % and 95 %.

Influences on the Precipitation Process

In the spray absorption process, the following parameters have a positive influence on the flue gas conditions for dust collection in an ESP:

- Lower gas temperature
- lower gas volume
- higher moisture content
- lower resistivity
- higher electrical field strength (Figure 5).

Operating experience with such systems has shown that the expected separation efficiency is obtained. On the whole, the actual values of the clean gas dust content have remained well below the designed clean gas dust contents. Values of 0.004 gr/scf (10 mg/Nm³) are common.

However, these favourable emission values can only be achieved if the discharge and collecting electrodes as well as the equipment for uniform gas distribution are free of large dust deposits. Some difficulties have been encountered in these areas.

Dust Deposits

Sulfur dioxide absorption by Ca(OH)₂ increases as the difference between the flue gas temperature and the water dew point is decreased. On the other hand, with the decrease of this temperature difference there is a risk of moisture forming in the dust cake leading to reaction products on the electrodes. Also, secondary reactions take place which may lead to crust-like deposits. Here the chlorine content of the coal is significant.

Calcium chloride (CaCl₂), a very hygroscopic substance, forms and chemically activates the dust cake.

Eventually, compact and partly very hard dust deposits are produced which can no longer be removed or avoided by the rapping systems used for the discharge electrodes and gas distribution internals (Figures 6 to 8).

The photographs show, to some extent, elaborate and unique formations on the discharge electrodes. These patterns partly depend on the shape of the electrodes and the formation of the electric field and the configuration of the electric wind.

In plant "A" burning imported coals of varied compositions, dust deposits were first found on the discharge electrodes. These deposits reached the thickness of a few inches but were not very compact. The temperature difference between the flue gas and the water dew point was 18 to 32F (10 to 18 °C). When buying the coal special attention was paid to a low chlorine content, i.e. less than 0.05 % average.

Various tests were conducted to improve the cleaning effect of the discharge electrode rapping system. The final solution was rather simple. An increase of the rapping frequency to three times its value, in the long term, prevented the formation of the dust layers shown. There has never been a problem with this installation keeping the collecting electrodes and gas distribution internals clean.

Plant "B" burns high ash coals from nearby mines. The chlorine remains above 0.1 %. Regulations stated that the desulfurization efficiency must reach about 93 %.

Therefore an attempt was made to adjust the difference between the flue gas temperature and the water dew point to between 18 and 27F (10 and 15 °C). With this mode of operation, dust deposits soon appeared primarily on the discharge electrodes of the first field and to a lesser extent on the gas distribution internals. The deposits were very hard and difficult to remove. Improvements to the existing rapping system were not sufficient. The discharge system used, consisting of discharge electrodes in tube frames, allowed no further increase of the cleaning forces produced by the drop hammers.

The design concept of the discharge system was modified, based on knowledge that the collecting electrode system could be kept virtually free from dust cakes (Figures 9 & 10). Therefore, using discharge electrodes similar to the collecting plates promised to be successful. This is the reason the so-called "Corostab" discharge electrodes were first used on an experimental basis in some lanes and then in the entire first precipitator zone. They are mainly self-supporting, punched and shaped bar-type electrodes and are bolted with their respective support, rapping and guide beams which allows transmission and distribution of the rapping energy with little loss. The entire system was designed to be so stable that higher rapping energy could be applied, i.e. heavier hammers could be used.

With these measures the discharge system cleaning was again under control. The electric charge used for the discharge current could be normalized again and the separation efficiency could be kept at a high level.

Gas Distribution

Gas distribution was achieved by several perforated plates arranged in series. The free cross sections ranged from 40 to 70 % and the hole diameters ranged from about 2 to 2.4 in. (50 to 60 mm) (Figure 11). It was soon obvious that hard dust cakes formed on the perforated plates. In extreme cases, extensive clogging occurred over wide perforated plate areas. Improvements of the suspension and fastening of the perforated plates aimed at increasing the ability to vibrate and thereby the cleaning effect were not as successful as had been hoped.

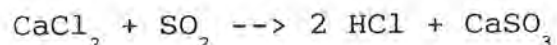
Eventually, the perforated plates were removed and replaced by steel sections crossing each other (Figure 12). These consisted mainly of steel angles as well as flat bars and channels. The free cross section remained unchanged, but the individual openings were enlarged to about 5 x 4 in. (120 x 100 mm).

This concept proved successful as far as the cleaning intensity and the uniformity of gas distribution are concerned.

Corrosion

After approximately one year of operation, another serious problem was evident. Excessive corrosion appeared on the collecting electrodes primarily in the first field. Within this field it decreased over the height as well as the depth. The corrosion rate was found to also diminish considerably across the entire precipitator length towards the precipitator outlet.

Extensive chemical and process investigations revealed that the corrosion mechanism is largely influenced by the chlorine content of the coal and/or other chemical compounds resulting from this chlorine content. The hydrochloric acid resulting from the combustion of chlorine combines with Ca(OH)_2 but is set free again in the presence of SO_2 and water. Simplified, the following reactions can be assumed:



The hydrochloric acid set free provokes the observed corrosion (Figure 13).

An explanation of the observed corrosion phenomenon in the bottom area of the first field is that the dust content is highest in this area. The rapping efficiency reaches its maximum in this

area and the well cleaned metal surface of the collecting electrodes is constantly exposed to new aggressive gas or dust (Figure 14).

Process measures such as preheating the ESP installation prior to startup, drying during shutdown periods etc. did not bring a lasting success.

Therefore the focus was placed on the selection of suitable material. Finally, the assessment of sample plates of material placed in the flue gas showed that the material with the designation 1.4462 (commercial designation: 2205, old German symbol: X2 CrNiMoN 22 5 3) promised the best results as far as life is concerned (Figure 15).

analysis: C < 0.03; Cr 21 - 23; Mo 2.5 - 3.5; Ni 4.5 - 6.5;
Mn < 2.0; N 0.08 - 0.2; P < 0.03; S < 0.02;
Si < 1 [%]

This material has proved successful after two years of operation. No material corrosion has been found.

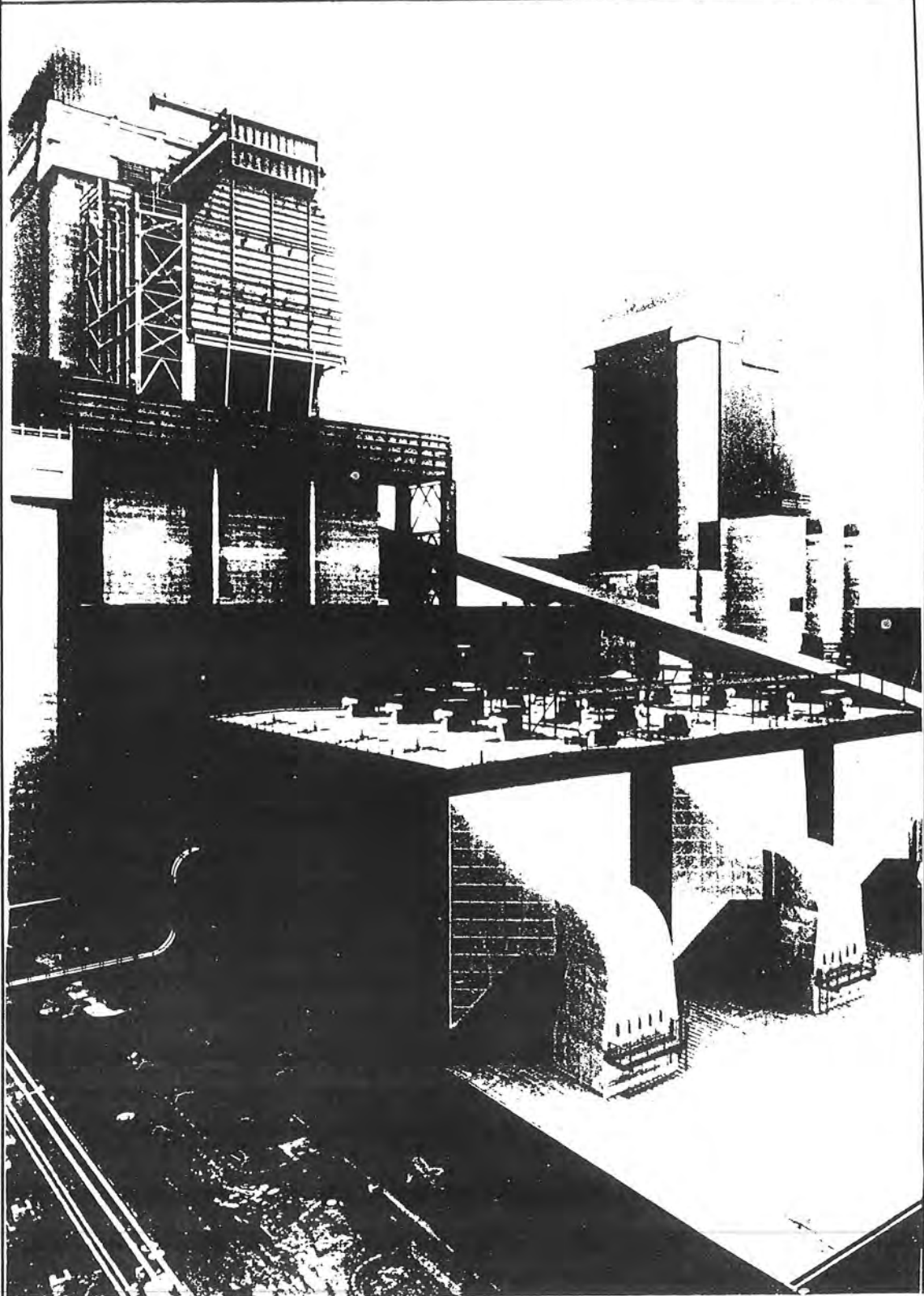
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2. N. Seyfert. "Plattenklopfung im Elektrofilter bei feuchten Gasen." Staub 49, pp. 401-405 (1988).
3. D.P. Tonn and R.W. Kronenberger, "Particulate Emissions Regulations on Low Sulfur Coal-Fired Units with Electrostatic Precipitators," Meeting IGCI Forum 91 (1991).

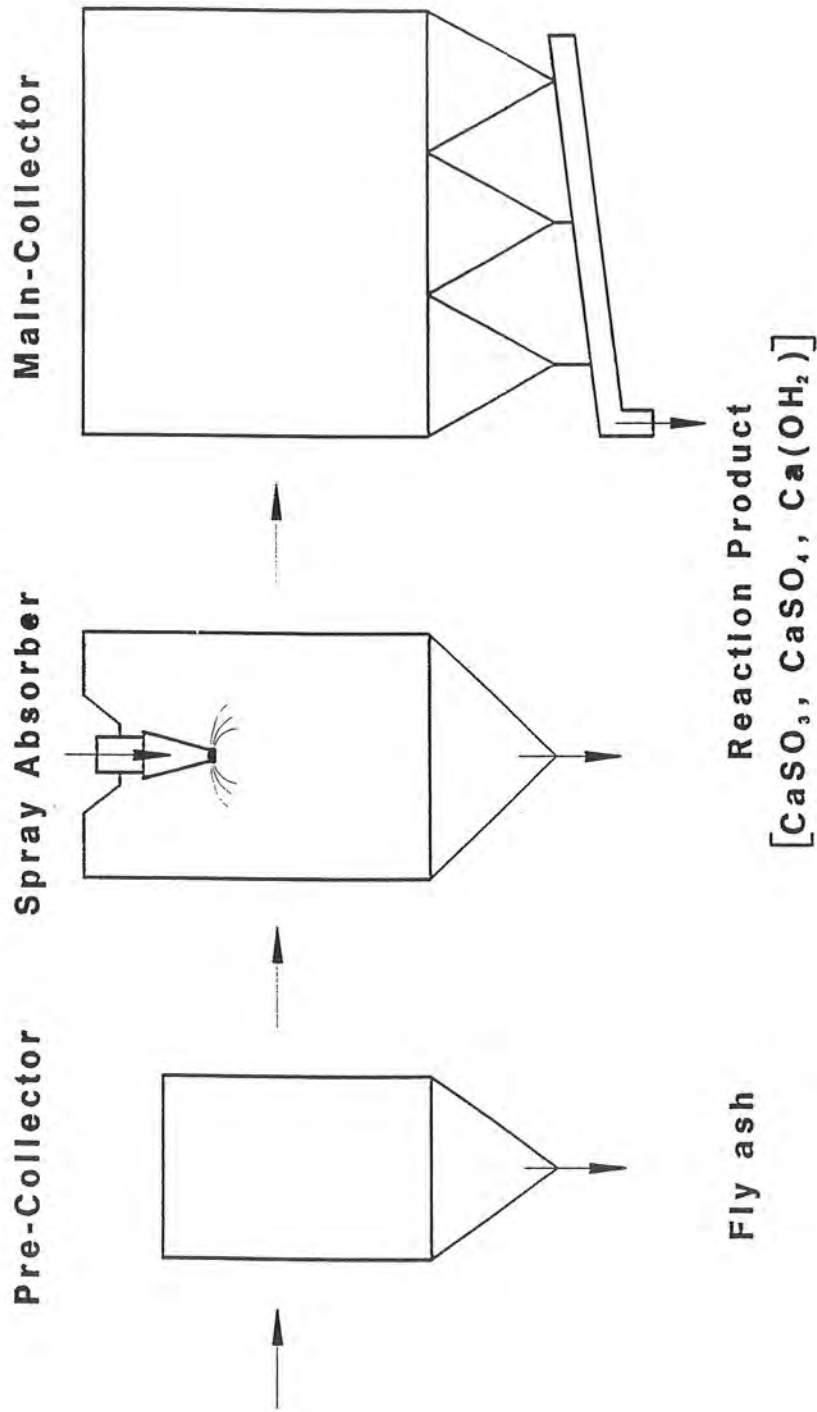


ROTHEMÜHLE

FIGURE 1

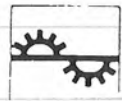


Schematics of Spray Dryer Process



ROTHMÜHLE FIGURE 2

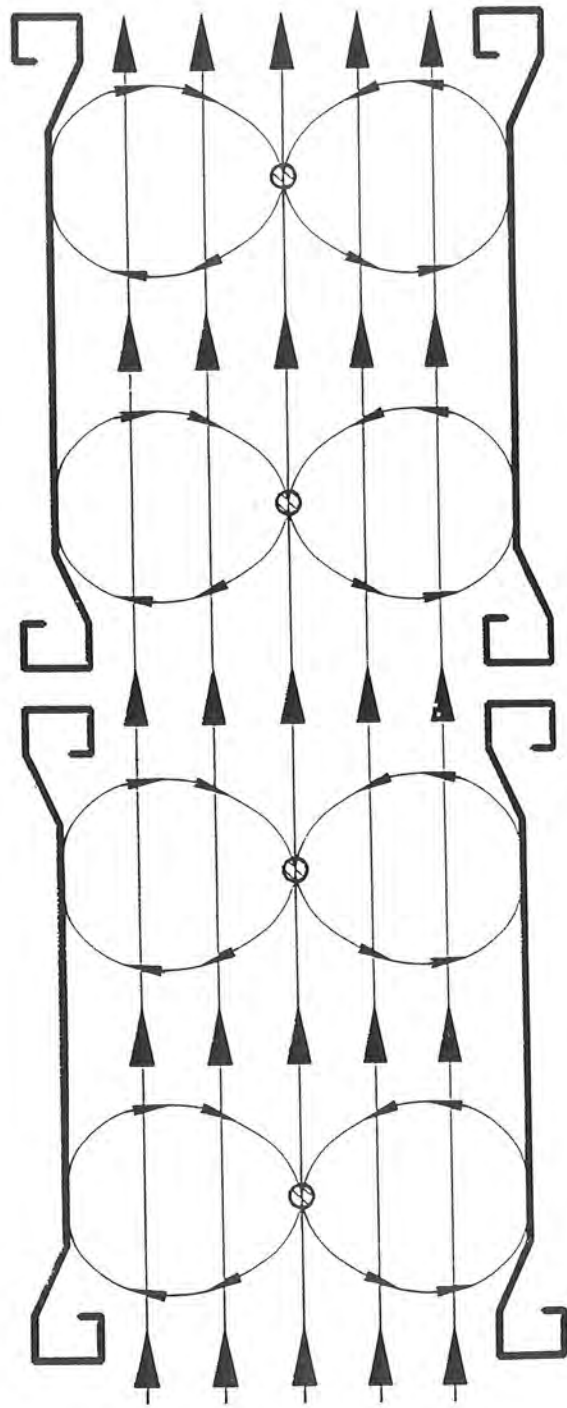
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FIGURE 3

Electric Wind Function



ROTHEMÜHLE FIGURE 4

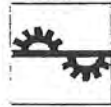
Lower Gastemperature

Lower Gasvolume

Higher Moisture Content

Lower Resistivity

Higher Electrical Field Strength



ROTHEMÜHLE **FIGURE 5**



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FIGURE 6

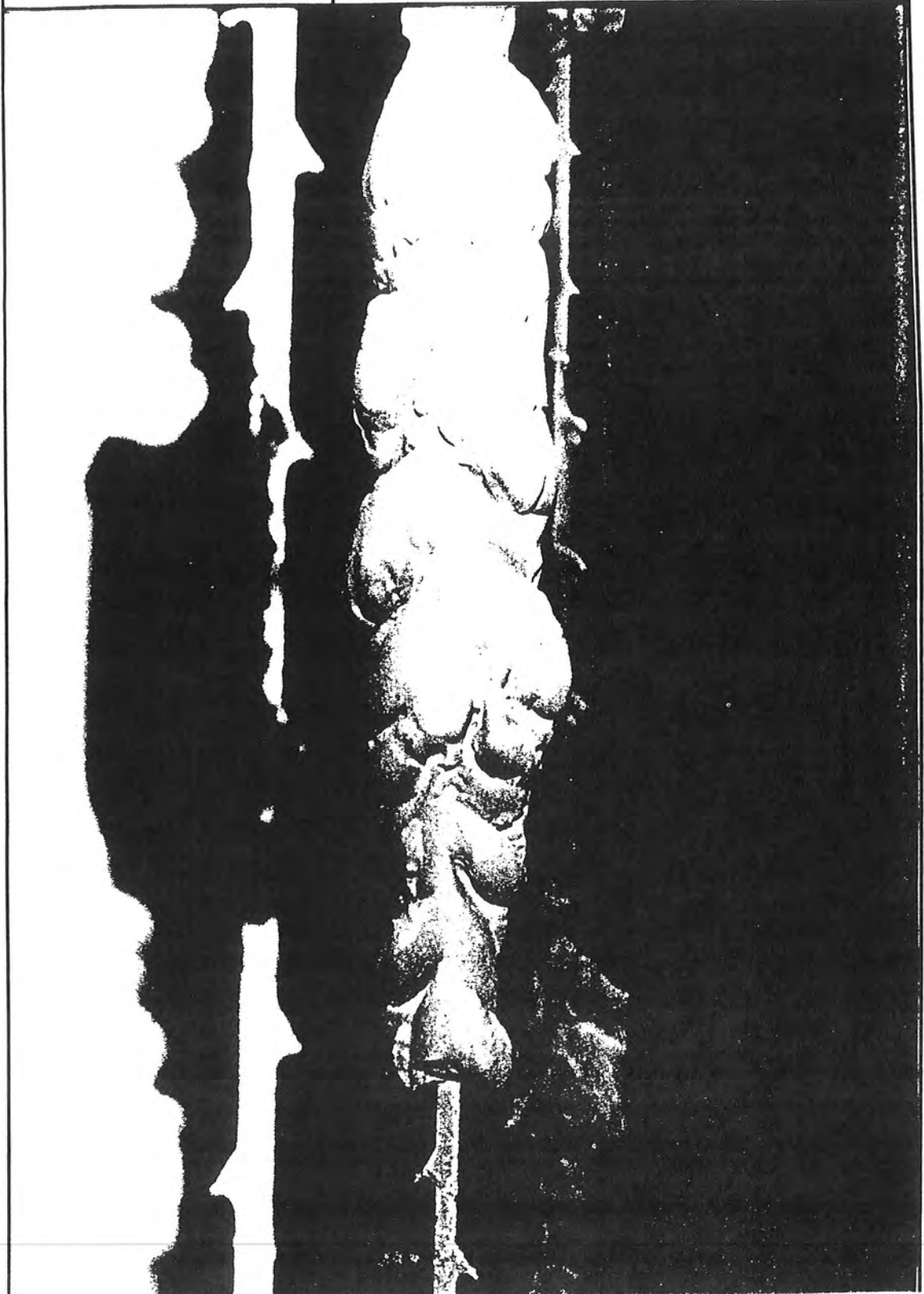
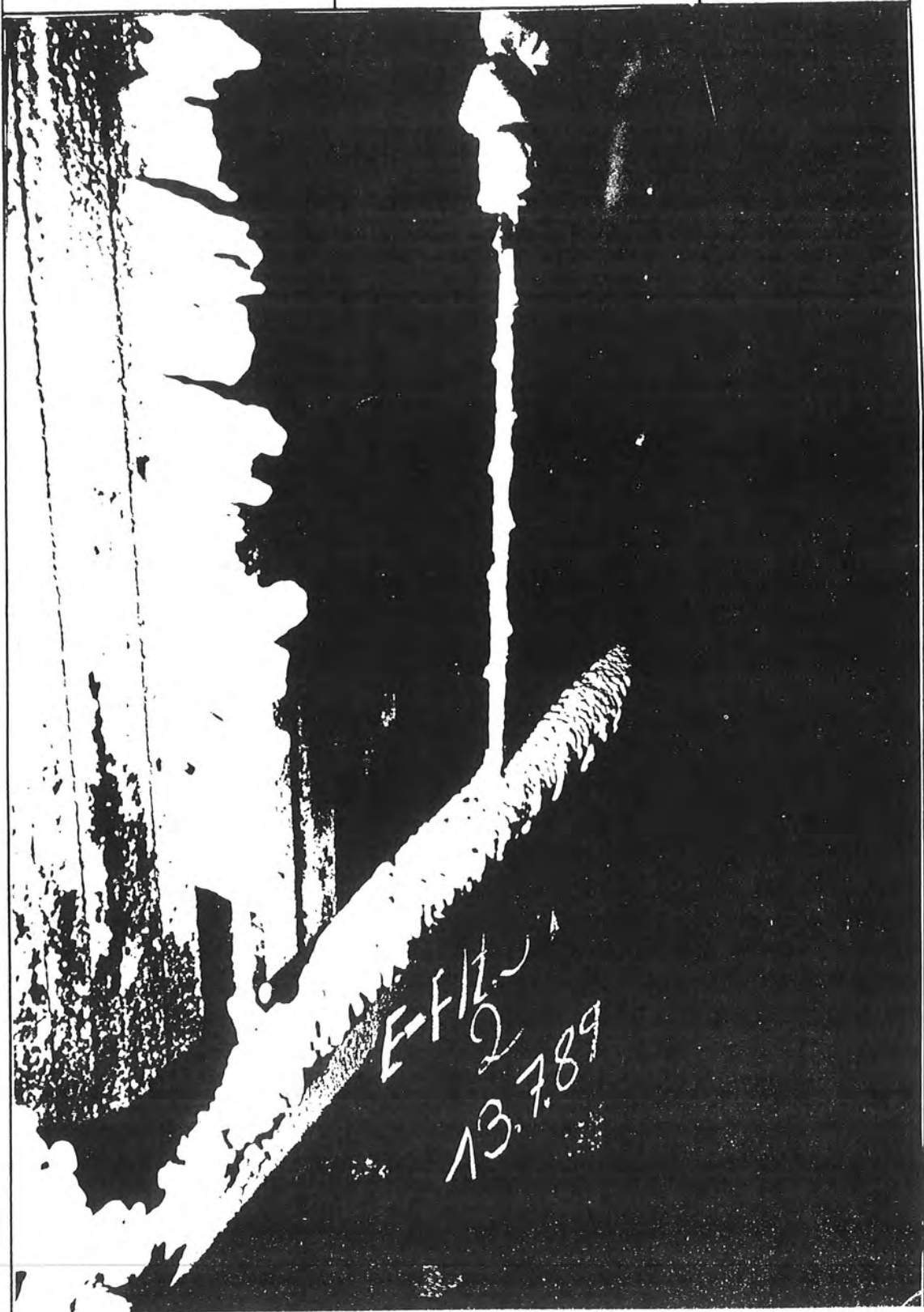




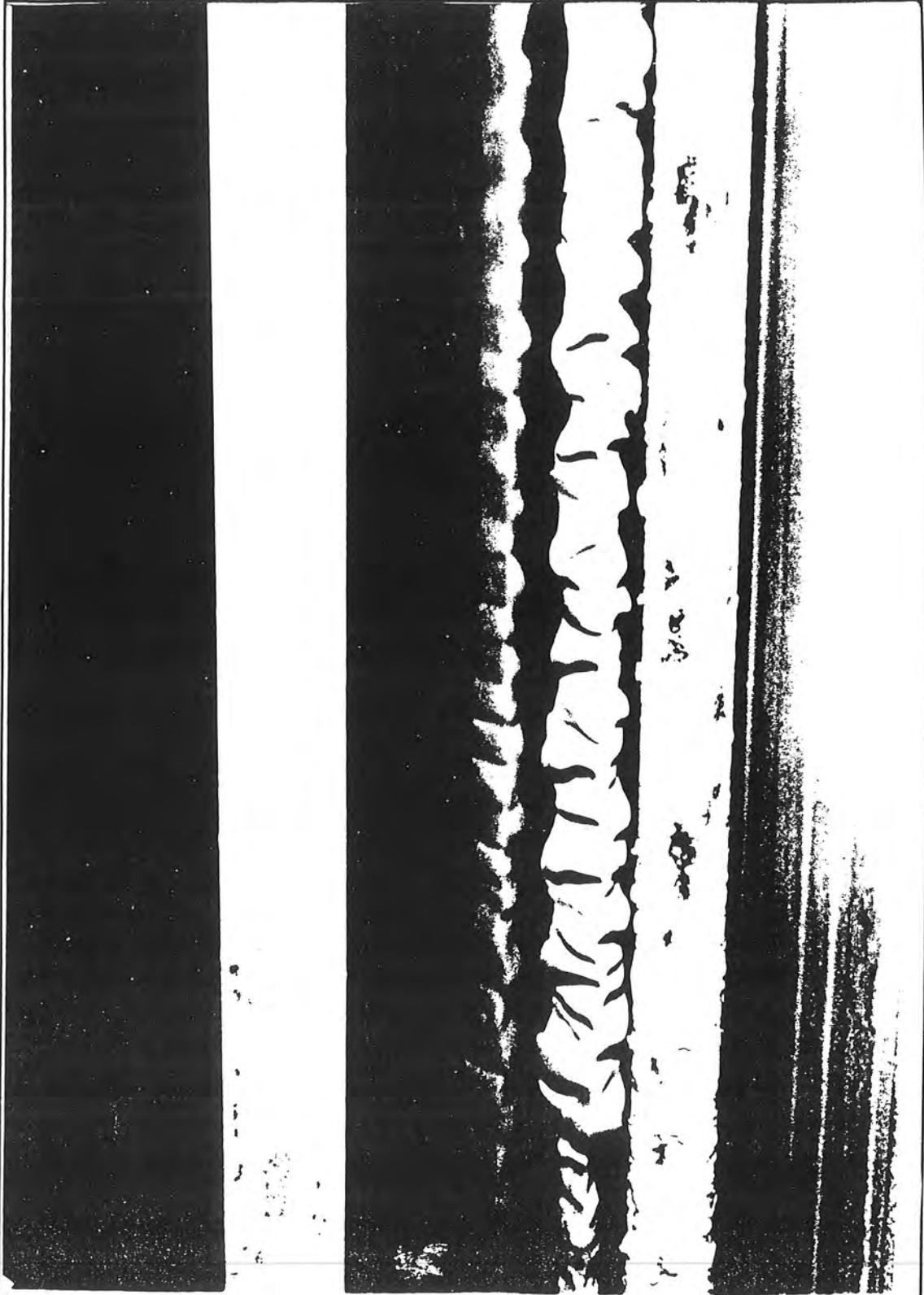
FIGURE 7





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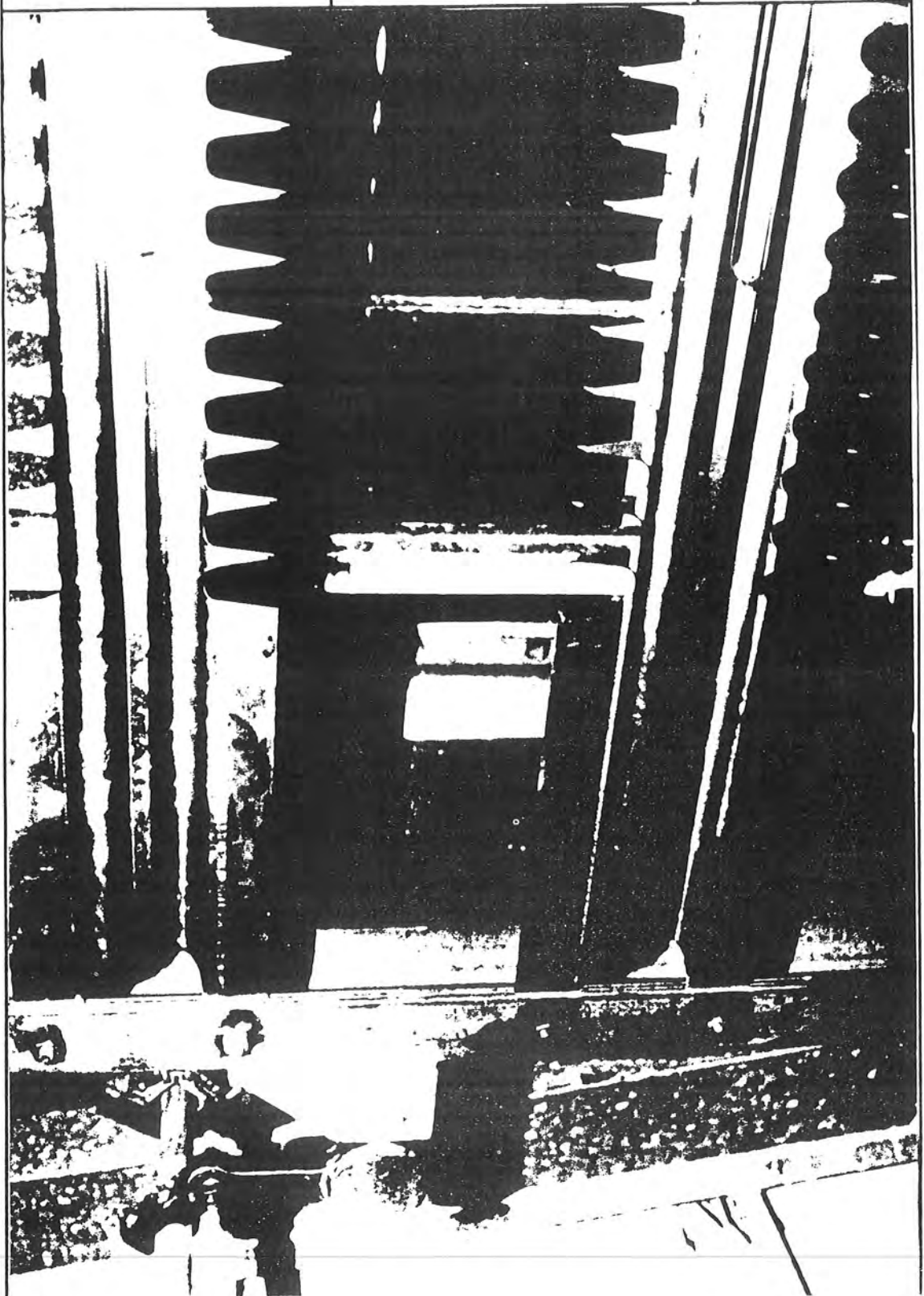
FIGURE 8

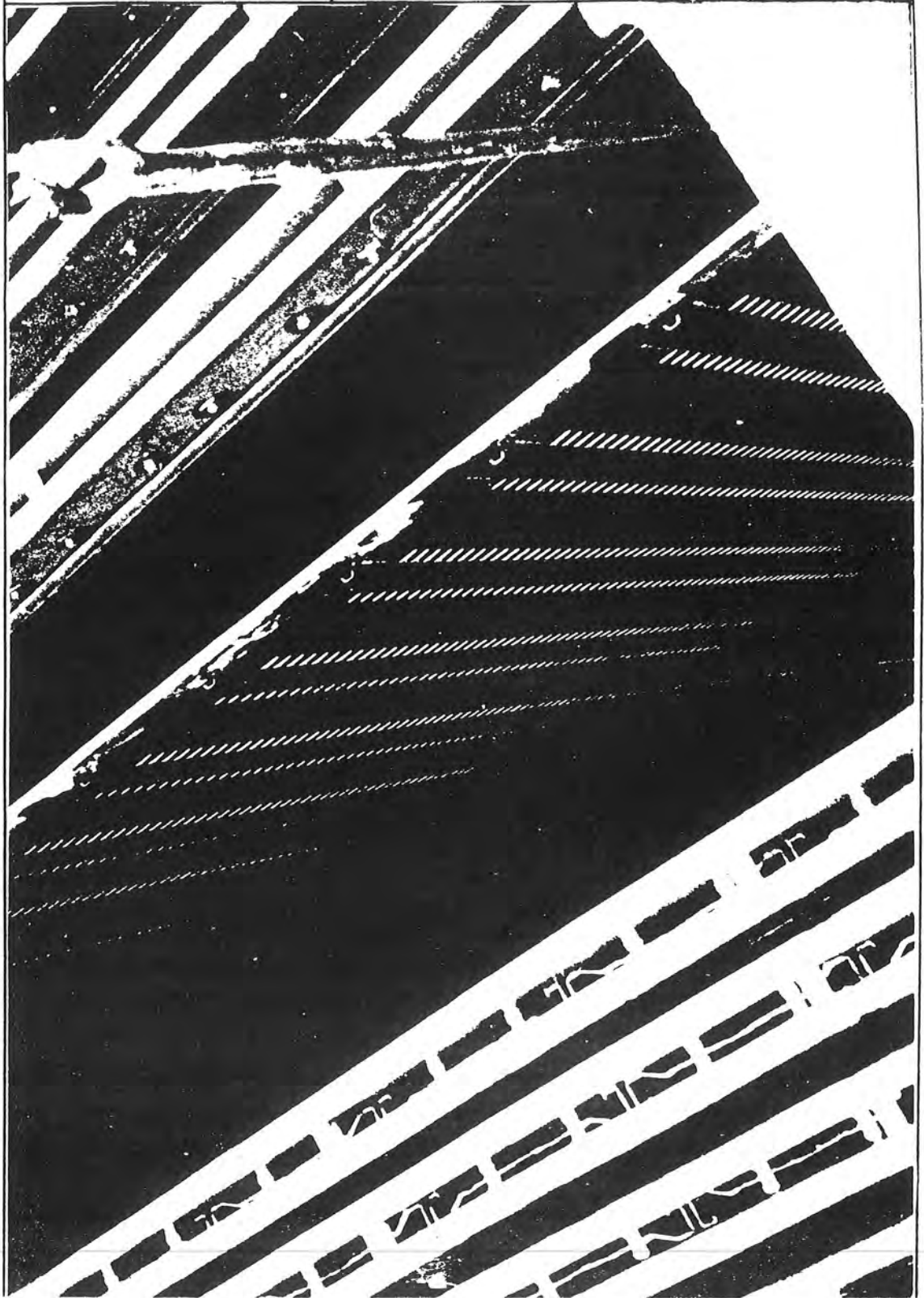




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FIGURE 9

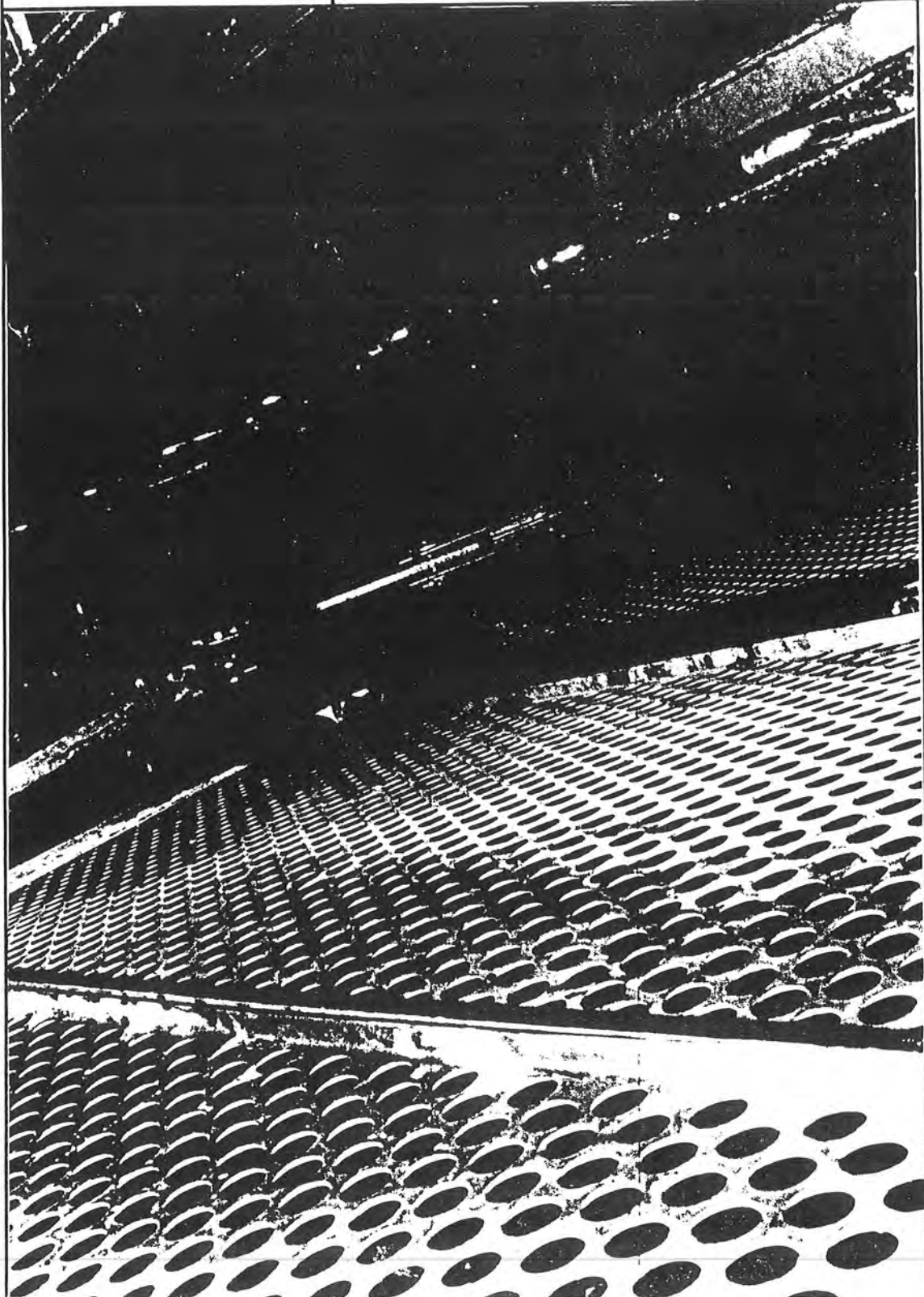






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FIGURE 11



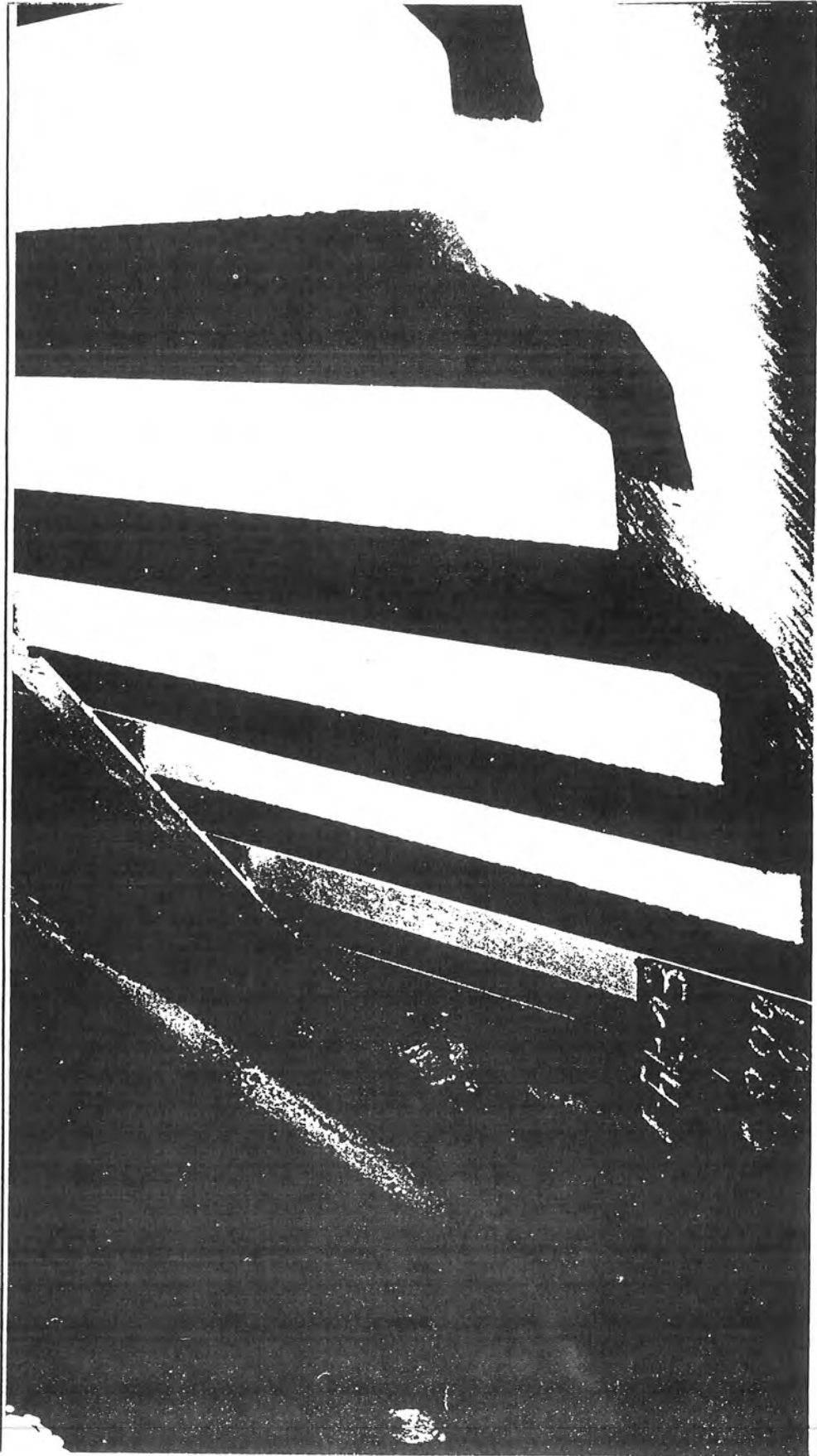
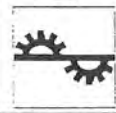


FIGURE 12

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Chemical Reaction in Spray Dryer Process

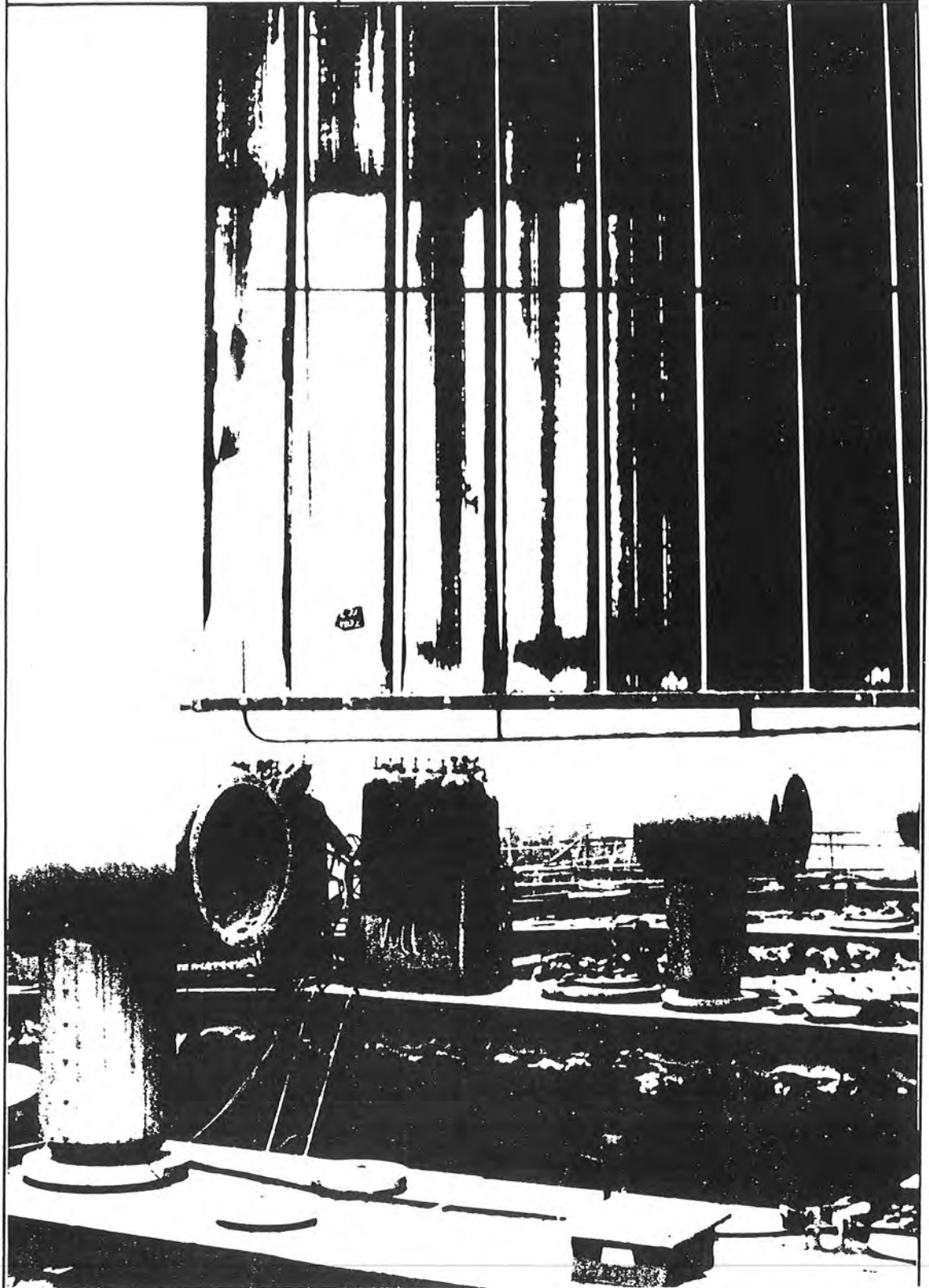


ROTHENMÜHLE FIGURE 13



ROTHEMÜHLE

FIGURE 14



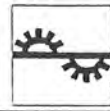
Electrode Material

Commercial Designation : 2205

Actual German Designation : 1.4462

Former German Designation : X2 Cr Ni Mo N 22 5 3

**Analysis: C < 0,03; Cr 21-23; Mo 2,5-3,5;
Ni 4,5-6,5; Mn ≤ 2,0; N 0,08-0,2;
P ≤ 0,03; S ≤ 0,02; Si ≤ 1; [%]**



ROTHEMÜHLE FIGURE 15