the problem finally narrowing down to blast roasting and nodulizing. It was found by experiment that blast roasting would not yield a satisfactory sinter without the addition of coke dust or sulphide fines to augment the fuel value of the flue dust, and on this account, together with the low cost of a kiln, the latter was decided upon.

"Two tons of flue dust was tried out in the experimental kiln in the laboratory at Yorktown, Va., of J. H. Payne, who acted as consulting engineer in this connection. This kiln was approximately 2 ft. in diameter and 20 ft. long and was fired with fuel oil. A run of several hours yielded excellent nodules. The kiln showed no tendency to build in and form 'nose rings,' and gave a fuel consumption of 50 gal. of oil per ton of flue dust. There was no indication of any stack loss. The roasting was strongly oxidizing. A study of what full-size kilns were doing on cement clinker and on nodulizing pyrites cinder indicated that a 60 by 6 ft. kiln would certainly not consume more than one-half of the oil per ton of flue dust shown on the test and as fuel oil at that time was selling around 2½ cents a gallon, it was decided to let it go at that.

"A 60 by 6 ft. kiln was decided on, as that is standard in cement practice, although fast being replaced by much larger ones with their greater fuel economy, and as it fitted in the building space available. A 6-in. brick lining brought the net diameter down to 5 ft. The inclination toward the discharge end was fixed at ⅝ in. to the foot, and the revolutions per minute at 1½.

"The results, while satisfactory, were quite different from those anticipated. In the first place, the fuel consumption was far lower than had been expected. A granular sand can be made with perhaps 8 gal. per ton, a first-class smelting product with 12, and great chunks with 16. It appears, therefore, that such a test kiln as that used takes about four times the fuel that will be required on a 60-ft. installation, although this ratio might be changed for different material with varying internal fuel values.

"In the matter of formation of nose rings, the test kiln was deceptive. There was a decided tendency to such formations and it took some time for the operators to acquire the necessary skill to control this. Steady conditions of flame are very necessary. If the kiln is overheated, semi-molten material forms on the walls and a subsequent over-chilling will plaster the sand on very rapidly. A number of devices were tried to meet this difficulty, but finally it was found that reasonable skill and care on the part of the attendant and an occasional shut-down of a few hours to remove any obstinate obstruction were the best remedies. . . . When perfectly clean 75 tons of flue dust can readily be nodulized in 24 hours, while a choked-up barrel will deliver less than one-half of this quantity. There is no difficulty in regular work in delivering 50 tons a day, including all delays, and a few hours' work for two or three men once in two weeks will handle the accretions."

Nodulizing Concentrates at Braden.

In discussing Mr. Addick's paper, Mr. James H. Payne, Baltimore, Indiana, first outlined further experimental work he had done on flue dust and then continued:

"In the early part of 1914, I succeeded in interesting the Braden Copper Co. in nodulizing, with the result that an extensive series of tests were made in Yorkton upon oil-floated concentrates covering quite a wide range in analysis. These tests led to trials in the Chrome rotary, on the part of the U.S. Metals Refining Co., of Minerals Separation concentrates which they had in stock, and later to test runs to check up the Yorkton runs on Braden concentrates. The large-scale tests checked up with the Yorkton tests in every way (except fuel consumption, which was, however, correctly predicted), and led to the Braden Co.'s decision to adopt the process at Braden.

"The fuel consumption upon oil-floated concentrates is not more than 6 gal. per ton, and in many cases is less. The action in the furnace is independent of the sulphur content, and there is actually less tendency to form nose rings in the Chrome rotary than upon flue dust. It is believed that the improvements entering into the design of the Braden kilns will cut down the nose-ring trouble to where it will no longer be a drawback to the process.

"The flue dust produced by the kiln itself is practically nil, although some of the material treated has been as fine as 82 per cent. through 100 mesh. This is unbelievable to metallurgists familiar with the old Bruckner roaster, but the conditions are entirely different. The material is fed wet and what dust there is precipitates in the atmosphere of steam at the exit end. The material, furthermore, is constantly moving downward to the hot end and is in a dry, dusty state but a short time, soon changing to a densified condition which is no longer dust.

"The amount of sulphur in the nodules is under perfect control. It can be as high as 15 per cent. or as low as 5 per cent., as may be desired. The upper limit for good working appears to be about 15 per cent., as the nodules are very sticky, with higher sulphur content. A product running 13 to 15 per cent. sulphur has been readily obtained on all oil-floated concentrates so far tried, where the object was to retain all sulphur possible. This makes pyritic blast-furnace smelting of sulphide concentrates possible.

"The size and character of the product has varied with the different concentrates tested so far, and also with the sulphur content sought for. When high sulphur is desired in the product, the nodules run smaller than the flue-dust nodules, as produced at Chrome. They are, however, entirely free from material that would blow out of a blast furnace. A number of samples tested show from 42 to 45 per cent. of voids.

"Nodulizing of sulphide concentrates, particularly oil-floated concentrates, opens up a new field because it makes possible pyritic smelting of such material. Further, the operation appears to be such a cheap one that it may compete with roasting in multiple-hearth furnaces in reverberatory practice. If so, it would be far preferable to roasting in the case of the exceedingly fine-oil-floated concentrates, because of the large amount of dust that the roasters must necessarily produce on this material."

Success at Chrome on El Cobre Concentrates.

Mr. R. M. Draper also took part in the discussion, as follows:—

"The kiln will treat El Cobre flotation concentrates very successfully. There does not seem to be much of a tendency to form ring accretions, and those that do form are nearer the discharge end of the kiln, where they may be removed much more readily. The temperature of the kiln is much lower for concentrates than for flue-dust, and the oil consumption much less. Our consumption of oil was about 6 to 7 gal. per ton of concentrate.