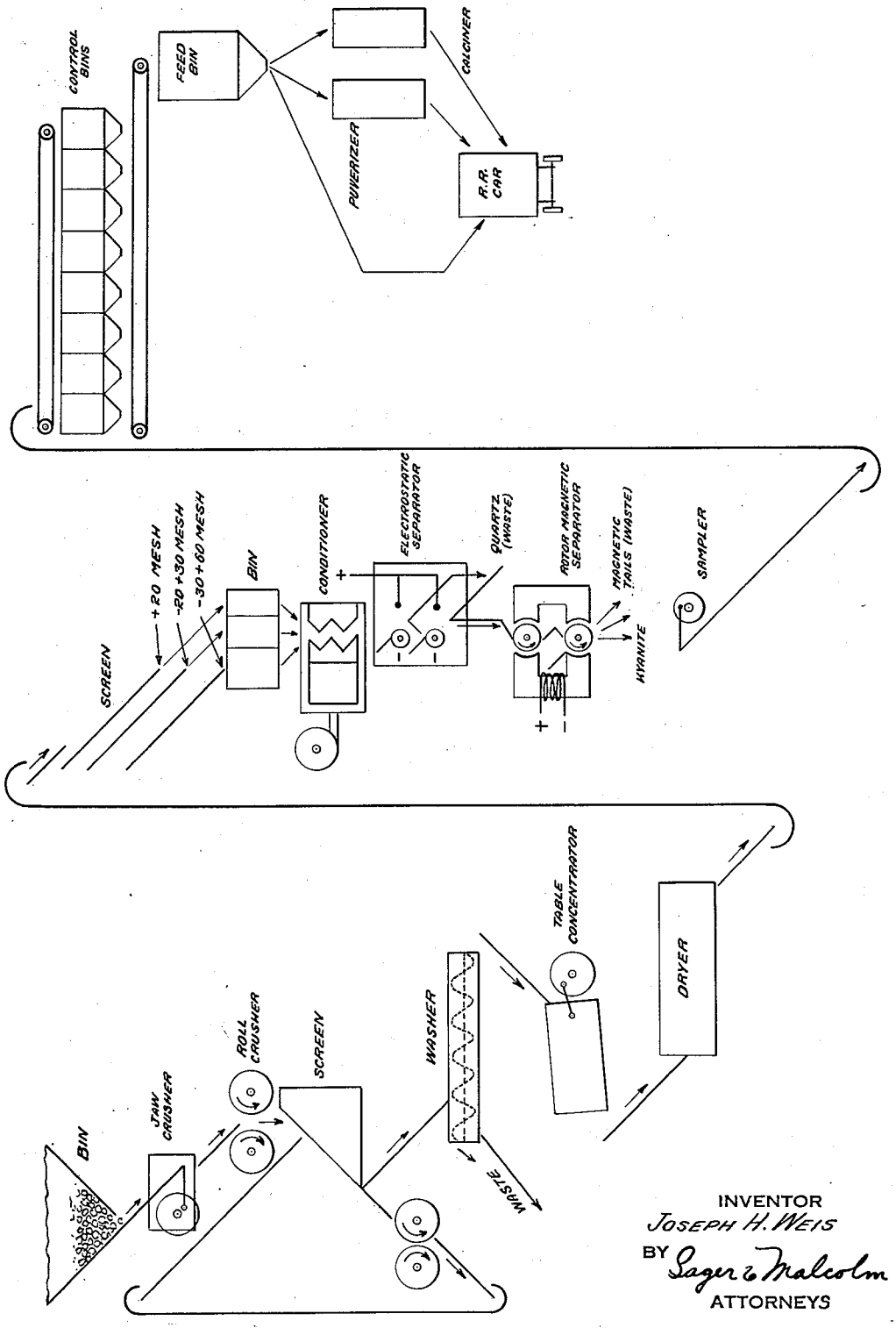
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PROCESS FOR PRODUCING KYANITE

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PROCESS FOR PRODUCING KYANITE

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This invention relates to the art of ceramics and has for its object to produce a uniform raw material of definite predetermined composition suitable for use in ceramic wares.

Another object of the invention is to produce a concentrated kyanite product from low grade ores which have heretofore been considered unsuitable for this purpose, and, more specifically, to produce a higher grade kyanite product containing fewer associated impurities than any heretofore produced from domestic mineral deposits.

Kyanite is aluminum silicate ($Al_2O_3 \cdot SiO_2$) and the theoretically pure mineral contains 63% Al_2O_3 and 37% SiO_2. Although kyanite has the same composition as andalusite and sillimanite, it differs from these minerals in certain of its physical properties.

Kyanite is a metamorphic mineral and occurs chiefly in gneises and schists and is generally associated with corundum, andalusite, staurolite, beryl, rutile, hornblende, ilmenite, garnet, micas and quartz. The five latter materials are the more common impurities and, in addition to these impurities, feldspar is sometimes present. In many instances the deposits are heavily stained with iron and may contain iron oxides, the latter condition generally existing at the top of a deposit. Because of its association with these impurities, all of which tend to lower its quality and produce harmful results in ceramic products, kyanite must be carefully processed and concentrated before it can be used in the manufacture of white ware and the like. In many instances kyanite comprises only 4 to 10% of a mineral deposit, and, as the bulk of the deposit must be removed as an impurity, and since most of the impurities are silicates with somewhat similar physical and chemical properties, the problem of efficient separation is a very difficult one.

My invention makes possible the utilization of bodies of gneises and schists which have heretofore been entirely unsuitable as sources of kyanite. In addition, pegmatite lenses, which are sometimes found to contains massive kyanite, can also be processed according to my invention to provide uniform shipments of this material. Likewise, placer deposits which contain kyanite heavily stained with iron can be utilized to produce a high grade ceramic raw material. The invention will be described in connection with the accompanying drawing which is a diagrammatic flow sheet illustrating the process.

The process illustrated by the flow sheet is generally applicable to most kyanite ores although, in some instances, some of the steps can be omitted. For example, where a comparatively low grade output is acceptable to the trade, most of the impurities can be removed by gravity tables followed by magnetic separation. In other instances, as where substantial amounts of clayey minerals are present, the ore is preferably washed after granulation and the clayey minerals floated off. The washing of the ores in log-washers or the like is an important step in the processing of placer deposits as well as deposits containing surface stained materials which have been considerably weathered.

In carrying out the invention according to the accompanying flow sheet the material is mined and stored in large crude ore bins. When there are differences in the deposit, or when the material is mined in different deposits, the various grades of ore are preferably stored in separate bins and the contents of each bin are processed separately to aid in the production of a uniform product, which is one of the principal objects of this invention. By means of jaw crushers, cone crushers and rolls, the crude material is first reduced to a granular form of such size that the kyanite crystals separate from the remaining minerals. Generally the kyanite crystals are larger in particle size than many of the impurities, and, being harder than many of the impurities, these crystals remain in their original form. This is probably due to the fact that the crystals of kyanite do not weather as easily as the other softer minerals. Because of this condition I find that it is generally desirable to discard the finest particle sizes, especially as this precaution results in very little loss of kyanite. I generally prefer to discard sizes smaller than minus 60 mesh, but this is determined by the nature of the deposit, and in some instances it may be desirable to discard a coarser particle size or a finer particle size, depending on the smallest particle size or range of sizes in which the kyanite separates from the mass. This step of removing the fines from the product is carried out by sizing apparatus such as screens, or, when the product is washed after granulation, the fine material carried off by the water is discarded.

At this stage of the process the material, which is in the form of generally minus 8 mesh plus 60 mesh, is next closely sized into separate batches each containing particles of substantially the same grain size, as, for example, such sizes as minus 8 plus 20, minus 20 plus 30, and minus 30 plus 60 mesh. This close sizing results in a more

efficient separation of impurities in the subsequent steps of the process. Each sized batch of the product is now in a form suitable for feeding to gravity table concentrators, high intensity magnetic separators and electrostatic separators as illustrated in the drawing. In processing kyanite ores containing substantial amounts of mineral impurities but with a minimum of clayey minerals, the washing step is omitted, as washing is used only for removing the clayey ingredients which generally contain considerable iron stain. The various sizes of material are stored in separate bins and these sizes are fed separately to gravity table concentrators and the resultant product, after removal of lighter minerals, is fed to a magnetic separator of the high intensity induction rotor type, which separator removes those minerals which are susceptible to magnetic attraction, among which are the various micas, garnet, hornblende and iron oxides.

In some cases it is desirable to omit the step of concentrating with gravity tables and to pass the sized material through a conditioner where it is heated and subjected to the fumes of an acid containing a fluorine radical such as hydrofluoric acid or silicon tetrafluoride, after which the resulting product is passed through an electrostatic separator where the quartz is removed. This treatment with hydrofluoric acid in the conditioner renders the kyanite and quartz selectively susceptible to electrostatic separation and results in a more complete removal of the quartz than would otherwise be possible. The material treated in this manner is then passed to the magnetic separator, after which it is passed over the table concentrator and the resulting product is in a purer form than when the step of electrostatic separation is omitted. The arrangement or order of these steps is dependent upon the nature of the impurities to be removed. The electrostatic separation with the accompanying conditioning step is particularly desirable where the content of free quartz is high and the other impurities are present in relatively small amounts. The step of washing the granulated ore is desirable when clayey minerals are present. The gravity table concentrators are used when the ore contains minerals not susceptible to electrostatic or magnetic separation. In some instances it is necessary to employ all four steps, although magnetic separation is generally used with one of the concentrating steps as the Fe_2O_3 content of the finished product must be reduced to a minimum because of the harmful fluxing and discoloration effects produced by Fe_2O_3 in kyanite.

After the material has been concentrated as described above and is in a granular form of high kyanite content and low iron content, the product is next passed through an automatic sampler before being stored in bins. The stored product consists of the separate sizes or the mixed sizes, depending on the consumers' specifications, especially as to particle size. If the consumer desires a calcined product, the coarser sizes are blended to produce a composition of definite analysis, and after calcining in a rotary kiln the resultant product may be passed through a pulverizer to reduce the particle size, depending upon the consumer's wishes. Generally, however, after the product has been sampled and stored in separate bins, batches from various bins are removed in definite amounts and mixed thoroughly to produce a product of definite composition. This mixing is carried out with batching equipment or else a weighing conveyor is employed. The steps of calcining and pulverizing are optional, depending on the consumers' specifications. When used in white wares, the consumer generally specifies a calcined and sometimes a pulverized product, which is finer than the sizes at which the various separations are made.

The finished product is now in a comparatively pure form, and this product, as shipped, is of a definite and known composition made to conform to consumers' specifications. This uniformity of the finished product is an essential and necessary step in the concentrating and processing of kyanite ores according to my invention. Since the concentration of any mineral is not a perfect or consistent process, it is necessary to overcome this difficulty and supply to the consumer a finished product of uniform composition, and whose physical and chemical properties are always the same.

It will be evident to anyone skilled in the art that various changes and modifications may be made within the scope and spirit of the foregoing process and hence the invention is only to be limited in accordance with the appended claims when interpreted in view of the prior art.

The invention claimed is:

1. Process of producing kyanite of definite predetermined composition which comprises reducing kyanite ore to a granular condition such that the kyanite crystals separate from the remaining minerals, discarding particles of material smaller than about minus 60 mesh, sizing the remaining granular material into separate batches each containing particles of substantially the same grain size, subjecting the sized batches of material to the action of an acid containing a fluorine radical and then to an electrostatic field to remove quartz, subjecting the treated material to a high intensity electromagnetic field to remove magnetic impurities, storing the concentrated kyanite in a plurality of bins, analyzing the contents of the various bins, and blending the contents of said bins to produce a mix of uniform composition.

2. Process of producing kyanite of definite predetermined composition which comprises reducing kyanite ore to a granular condition such that the kyanite crystals separate from the remaining minerals, washing the granulated product to remove clayey minerals, removing particles of material smaller than about minus 60 mesh, sizing the remaining granular material into separate batches each containing particles of substantially the same grain size, concentrating and drying said sized batches of material, subjecting said sized batches of material to magnetic and gravity table separation to remove especially magnetic impurities and quartz, storing the purified kyanite in a plurality of bins, analyzing the contents of the various bins, and blending the contents of said bins in calculated quantities to produce a mix of desired definite composition.

JOSEPH H. WEIS.