pipe, with a socket on the end to receive the indicator cock. This indicator can be used in a horizontal position, but it will be found much more convenient to put in a bent pipe, and set it vertical. Sometimes it will be necessary to drill in the side of the cylinder at the upper end also, especially in double cylinder engines having parallel motions, when the indicator cannot generally be set on the covers. Care must be taken that the piston does not cover the hole when on the center. No putty is necessary to make these small joints, and it should never be used, as it is liable to clog the instrument. If the screw fits loosely, a few threads of cotton wound around the stem will prevent the escape of steam.

On horizontal engines, the best place for the indicator is on the top or upper side, at each end; if it cannot be placed there, bent pipes may be screwed into the covers or into the side of the cylinder. In other respects follow the directions given for vertical engines. The indicator should never be set to communicate with the thoroughfares. The current of steam past the end of the pipe or the hole reduces the pressure in the instrument, and the diagram given is utterly worthless, as any engineer can readily ascertain by making the experiment.

The stop-cock being screwed firmly in its place, screw the indicator down to its seat, turning it to the most convenient position, and make it fast by turning the coupling; then move the guiding pulleys to their proper position to receive the cord, and the instrument is in readiness for use.

BEET ROOT SUGAR.

No. X.

TECHNOLOGY.—PART VII.

FILTRATION.

"In loading" a filter, the metallic sieve is placed at the bottom of it, through the man-hole, and covered with a wet cloth. A layer of bone black a few inches thick is then carefully spread over the cloth, rammed down tight, and the man-hole door closed. The filter is then filled through the top by emptying the boneblack into it from sacks, until within 18 inches of the top. A coarse cloth fitted into a metallic ring is then spread over the upper surface of the bone black to prevent displacement or the passage of scums, and the cover of the filter tightly fitted on.

New bone black, containing soluble salts, and having a disagreeable flavor must be thoroughly washed before being used for the clarification of saccharine solutions. For this purpose the filter is filled with water (hot if possible), which, at the end of 15 minutes, is run rapidly out by opening the lower cock of the filter to its full extent. Hot water is much preferable to cold for the washing of bone black, as it increases its durability, and at the same time renders it more efficacious in the production of limpid, well-flavored sirups.

Bone black which has been used and "revivified" does not in general need washing before being employed for the filtration of carbonatated juice, but must always be so prepared before filtering sirups through it.

After a certain period of time, which varies according to circumstances, the bone black loses, to a certain extent, its power of purifying juice or sirups; this, for carbonatated juice, is known to have taken place when the filtered juice issues from the filter with a yellowish-brown color and an ammoniacal odor, and for sirups, when they loose their "golden" hue, and acquire an unpleasant flavor. In such cases the flow of saccharine fluid must be stopped, and the filter filled with hot water, which is allowed to run out until it marks from 1° to 1½° Baumé. The cock is then closed for fifteen minutes, at the expiration of which the liquid is again tested by means of the areometer. If the density has increased the quantity of water used has been insufficient. The bone black, after continued use, finally becomes "spent," after which no amount of hot water, alone, will return to it its clarifying properties.

The operation of filtration must be regular and continuous. If a diminution of the flow at the outlet should occur, this is produced by the obstruction of the meshes of the upper cloth of the filter by dirt, or by scums having agglutinated the upper layers of bone black. In such a case the bone black is taken up to a depth of two feet, replaced by new, and a fresh cloth put over it, when the operation is proceeded with as before.

The quantity received into the filter must always be the same as that which escapes from it, a matter easily regulated by the cocks for egress and ingress. In cases where bad juice or sirups are being worked it often becomes necessary to refilter several times in succession.

The juice from the scum department is run into the same filters as the juice from the carbonatating pans.

When the bone black has become "spent," the filter must be renewed. This is done as follows: In the first place, the upper layer of foul bone black is taken up with a shovel and laid aside; the filter is then emptied of its contents through the lower man-hole, and the lower sieves and cloth taken out. This is only done after the liquid from the filter has been brought by addition of water (after having stopped the flow of juice) to a density of 1° to 1½° Baumé.

The carbonatated juice is run into the top of a newly-washed filter until the liquid escaping through the bottom marks 1° to 1½° Baumé. The lower cock is then closed, and the juice allowed to gradually reach the top cock, which must first be opened to one-half and later to three-quarters of its extent, but not sufficiently to cause a disturbance of the solid contents of the filter. It is best to receive the juice of only one pan on a filter at one time. This necessitates the use of two filters for every three carbonatating or defecating pans.

The same filters which have been used for clarifying the sirups are employed for the same length of time, for the clarifying of the juice, but filters which have been used for juice must never be used for sirups.

Every time a filter is emptied its internal surface must be washed by dashing hot water into it by the bucket-full, and by rubbing with a wash rag. It is then to be white washed with weak milk of lime by means of a broom. The sieves must also be well scoured and limed.

The filtered carbonatated beet root juice is run from the filters into a *monte-jus*, which carries it to the reservoir of the concentrating vacuum pan; the filtered sirup is run into a *monte-jus*, which carries it to the boiling pan.

BONE BLACK.

This being a very important item in the manufacture of beet root sugar, will detain us a few moments.

The bone black used in this branch of manufacture is the average "grained" bone-black, not the pulverized such as is employed by druggists.

If of a good quality its color is a lusterless black, and it must very strongly adhere to the tongue when applied to it. It must weigh from 42 to 45 lbs. per cubic foot, if heavier it contains water or adulterations. Bone black which has been used once or oftener, and "revivified," has the bluish tint of slate, weighs heavier than new black, and is less porous.

After boneblack has become "spent" it may, to a considerable extent, be restored to a pristine energy, by being submitted to a special treatment, known by the name of "revivification," which we shall now proceed to describe.

After the "spent" bone black has been taken out of the filters, it is thrown in heaps, from whence it is taken to a bone black washing machine, revolving with a speed of 12 to 15 revolutions per minute, and having an incline of about 8 inches, through which runs a constant stream of hot water, which is obtained from the condenser of the vacuum pans. The black issues from this washing machine in an apparently dry state, and is received into baskets placed at its lower extremity, in which it is conveyed to an iron drying floor, heated by the waste heat of the bone-black furnaces. It is here laid in heaps of from one-half to two-thirds of a foot in thickness, and continually stirred both day and night.

When perfectly dry the bone black is placed into high, narrow, vertical iron retorts, placed in a furnace, and heated until these last acquire a peculiar "*brown-red* heat," at which degree the temperature must very carefully be maintained (by the management of dampers) for a period of twenty-five minutes. The contents are then dropped through the bottom of the retorts into portable sheet-iron receivers, or "smotherers," on which a tight-fitting cover is instantly adapted.

The bone black is then wheeled into a shed, through which the air freely circulates, and laid in layers, when it is immediately sprinkled with water from an ordinary watering pot, to exclude the possibility of its reigniting. As soon as the black has cooled down it is ready for use.

The muddy bone black taken from the upper portion of the filters and that which has been several times used is treated differently to what we have just described.

It is placed into wooden tubs, or vats, of a capacity of 200 cubic feet, more or less, and submerged in a mixture of water and muriatic acid, marking 2° Baumé. Effervescence, or as it is improperly called, "fermentation," soon sets in, and is concluded in 6 to 8 days.

The water is now drawn from the "fermented" bone black by means of a tap plug, and the black itself taken to the bone-black washer, from whence it goes to the drying floor and furnace, as before described. In many works the whole of the bone black used is both "fermented" and "roasted."

Bone black is known to be sufficiently washed when water, dripped from it, and placed in a clean tumbler, is perfectly clear and transparent after the deposition of the suspended fine particles has taken place.

The quantity of bone black needed, and the length of time it can be employed before becoming "spent" varies greatly with the nature of the beets and the degree of perfection of the previous defecation and carbonatation. The quantity must be so calculated as to include the quantities in process of revivification as well what is in actual use in the filters.

The average quantity needed, practically, is twenty per cent of the quantity of beets, by weight, worked up every twenty-four hours. A factory consuming 150,000 lbs. of beet root per diem would thus need 30,000 lbs. of bone black.

The residue from the bone-black washer is collected in cisterns where it deposits itself as fine mud, and constitutes a highly valuable fertilizer.

CRYSTALLIZATION.

The beet root sirup boiled to a consistency of from 40 to 42 deg. Baumé, more or less, is distributed into a number of iron forms or crystallizers of a capacity of about 12 gallons each. These are left quiet in an apartment the temperature of which is kept at 95 deg. Fah. At the end of eighteen or 20 hours the upper crust formed is punched through, and in from five to eight days the sugar is "made." If crystallization is progressing favorably, a thin "mirror" soon forms at the surface in the crystallizer, and at a later period this sirup covers to a certain depth the mass of crystallized sugar.

The contents of the forms are next emptied into "centrifugal turbines," revolving drums, the outer surface, of which is covered with metallic tissue through the meshes of which the sirups flow, by the action of the centrifugal force, while the crystals of sugar are retained within. These centrifugals are of various construction, but the velocity of their circumference must not be inferior to from 160 to 180 feet per second.

In a very short space of time the sugar (first product), is ready to be scooped out from the inside of the centrifugals.

If it be desired to make very white sugar, it must be further washed by means of a jet of fine spray or of steam while the turbine is in motion. This washing of the crystals of sugar injures the "grain" to a certain extent, by melting off their sharp angles. The *first* suger is kept separate from the second and third, being of superior quality. The sirup escaping through the meshes of the centrifugal is received in a *monte jus*, carried to a reservoir, and from thence to the boiling pan, when it is again reduced to a density of 40 to 42 deg. Baumé.

This *second* product is run into iron crystallization tanks of a capacity of 400 gallons each, and kept in a special apartment heated to 100 deg. Fah. In from eleven to fourteen days the *second* sugar is crystallized, when it is "centrifugalized" as was the *first*.

The sirups resulting from these "seconds" are in turn boiled to proper consistency, and collected into iron tanks of a capacity of 1,000 gallons. These are kept in a room at a constant temperature of from 100 to 112. deg. Fah., and from four to six months the "third sugar" is ready for working up.

The residue from the third sugar is *molasses*, and is collected into cisterns for the distiller's use.

After being broken up in a "lump-breaking" machine and passed through a screen the sugar is ready for market.

If the sirups from the *first* and *second* sugars are high colored, they will need clarifying. This is done by adding water to them until they mark from 28 to 30 deg. Baumé, heating by steam to ebullition in an open pan, with full open steam cock, adding half a bucket of ox blood (well beaten up with switches), or, in its absence, white of eggs or milk, and a pint and a half of fine "dust" bone black per thirty-five cubic feet of sirup. The scums are skimmed as they form, and are treated in the same way as the scums of defecation.

The clarified sirup is run through a special filter kept for the express purpose, and is then run into the boiling pans. Sirups from the first, second and third, must never be mixed together.

It is advisable to keep a bucket of cold water constantly in readiness near these boiling sirups during clarifying, so as to instantly allay, at any time, sudden foaming or too violent ebullition and consequent overflowing of the pan.

ESTIMATES FOR THE BONE BLACK DEPARTMENT OF A BEET ROOT SUGAR FACTORY WORKING 150,000 LBS. OF BEETS EVERY TWENTY-FOUR HOURS.—One bone-black furnace with 2,500 square feet (50 × 50) of drying surface and 14 elliptical retorts, cost, $1,100; bone washer, $110; smotherers, $112. Total, $1,322.

ESTIMATES FOR CRYSTALLIZATION DEPARTMENT.—Four centrifugal turbines of latest construction, $1,120; sugar crusher, 140; transmission of motion to turbines and crusher, $220; *monte-jus* and gutters, $190; one six-horse power engine running at a speed of 80 revolutions per minute, $380; three reservoirs for sirups of a capacity of 750 gallons, $180; two hundred crystallizers for "firsts," $520; twelve crystallizers for "seconds," $360; eight crystallizers for "thirds" $540. Total for crystallization, in gold, $3,550.

To the above estimates must be added: Piping and cocks for the whole establishment, $3,600; vats, $300; various tools, $1,000; packing and unpacking of machinery, $2,000—beside freight and duties on the whole apparatus, the total weight of which we have estimated to be about 200 tuns.

We have now reached the conclusion of the series of operations by means of which "raw sugar" is made from the beet root. In our next and last article we shall exhibit the amount of labor needed, and give careful estimates of what it would cost to produce beet root sugar in the United States.

For the Scientific American.

STATISTICS OF THE PRODUCTION OF IRON.

(Concluded from page 328.)

BY PROF. PETER TUNNER.

Among the non-metallic products of mines salt is the most important. We cannot take notice of its price in those countries where it is a monopoly, as in Austria, but taking its commercial price as a standard, it averages about one florin per cwt. Of less importance are sulphur, vitriol, alum, graphite, manganese, and tungsten, for the cost of which see particulars below. From the unity prices previously discussed, we infer the following values of yearly production:

	Florins.	Florins.
2,514,000,000 cwts. coal @ one-fifth florin	502,800,000	
640,000,000 " " @ " " for the manufacture of iron		362,800,000
60,000,000 cwts. coal @ one-fifth florin for all other products	140,000,000	
191,800,000 cwts. iron @ 4½ florins		863,100,000
45,883 mint pounds gold @ 675 florins	310,421,025	
2,893,000 mint pounds silver @ 45 florins	128,835,000	
1,581,000 cwts. copper @ 57 florins	90,117,000	
4,926,300 cwts. lead @ 12 florins	59,115,600	
2,350,000 cwts. zinc @ 9 florins	21,150,000	
All other metals together in the value of	30,800,000	640,438
80,000,000 cwts. salt @ 1 florin	80,000,000	
1,000,000 cwts. sulphur @ 4 florins	4,000,000	
Various vitriols and alums	3,000,000	
250,000 cwts. graphite @ ¾ florin 40,000 cwts. manganese 700 cwts. tungsten	500,000	87,500,000

It appears from this table that the yearly production of iron is represented by the immense sum of 863 million florins, or $431,500,000 gold. This sum exceeds the value of all the other metals, and it is larger than that of the aggregate of all other mineral products. The article next in value is coal, and it may therefore well be maintained that the iron and coal industries represent the two principal departments of human activity in the present age.

The production of the precious metals being chiefly confined to America and Australia, iron receives thereby a much higher importance in European industry than our first table seems to show, in which the productions of all countries of the world are compared with each other. It can, for instance, be proved that the value of the iron production in the Austrian empire is four times as large as that of all other metals; in Germany it is six times as large, etc. But this is not all. The variety of uses to which iron may be applied is surprising.