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SUGAR PRICES FOR THE MONTH ENDING MARCH 15, 1907.

	Centrifugals.	Beets.
February 15	3.38¢	8s. 9¾d.
February 22	3.39¢	8s. 11¼d.
March 1	3.435¢	8s. 11¼d.
March 8	3.53¢	9s. 1½d.
March 15	3.50¢	8s. 11¼d.

Messrs. Czarnikow, Macdougall & Co., in their reports of March 1 and March 8, report as follows:

At the reopening of the market refiners professed indifference to the offers put before them, but as Cuban sellers showed a determination not only to resist a further decline, but to claim a moderate advance, and as outside operators appeared ready to take everything that was immediately pressing upon the market, the attitude of refiners underwent a change. As the week progressed increasing interest developed and this interest culminated in very large transactions at 1/16c. over the prices obtained last week.

With Cuban sugars still .39c. under the Beet parity, the upward movement should make steady progress, as time passes, until the Cuban producer gets some portion of the preferential acceded him under the Tariff. That he is getting none of this preferential at present is the result of his forced selling, but now that so much of the crop has been marketed the selling pressure ought gradually to diminish. That refiners should require some inducement in price to lead them to buy sugars, which they must hold in store at this end for weeks or months, is not surprising, but it is obvious that the later we get into the season the shorter will be this holding time, and this, of itself, justifies a gradual improvement in prices.

The week closes with the market so well cleared of sugars that there is little on offer, and with sellers showing an inclination to hold back and await developments.

European Beet markets have been quiet but firm. Today's f. o. b. quotations are: March, 8s. 11¼d.; April, 9s.; May, 9s. 1d.; August, 9s. 3d.; next crop, October-December, 9s. 0½d.

Owing to the important bearing that European beet sowings have upon the future of the market, a great deal of interest attaches to the question often asked, whether they will be greater or less this year than last. Some time must yet elapse ere the question can be answered with accuracy, meanwhile Mr. F. O. Licht's remarks in his monthly report of 15th February may be of interest:

"Concerning the extent of the coming area cultivated with beets, up to the present little or nothing reliable can be said; the state of the winter sowings as well as the development of weather and labor conditions will play an important part in the near future, and, as a matter of course, the price movement of sugar as well as the valuing of the pure agricultural produce in the course of the next month will have considerable influence. The reports up to the present only speak of slight limitations, which a greater part of the large landed proprietors are likely to find necessary on account of the scarcity of field hands and the rise of wages; the middle and smaller farmers are inclined to dedicate a somewhat larger area to the cultivation of beets. Taking all in all, an important falling off of the last year's beet area is to be regarded as scarcely likely; it is quite possible that a slight increase is not altogether excluded."

The upward movement in our raw sugar market, which started ten days ago, has continued this week, and prices of Cubas for prompt shipment are today 5/32c. above the lowest point. Refiners have again shown that they consider it good policy to provide for future requirements by stocking up at what is still a low level, even although such stocking up may involve expenditure in carrying charges that will enhance the cost of their purchases by the time they are needed for meltings. That such enhancement of cost is likely to be offset by a considerably greater enhancement in value is a belief fully warranted by past experience, which has demonstrated again and again that a local depression, caused by a temporary over-supply, cannot permanently affect a market which must, ultimately, draw upon international sources of production and pay international prices before such drafts will be honored.

The slowness of the progress towards a higher plane is the best guarantee for its continuance. A too rapid advance would lead to a reaction which, in the end, might result in a lower general average price than that obtainable under a steady and gradual improvement like the present one.

Production in Cuba is still proceeding at a rate that makes a steady outflow of shipments a necessity, and sellers are wise in refraining from checking this outflow by demands upon buyers that would provoke resistance. Buyers are showing their willingness to pay higher prices as the season advances, and sellers are meeting them in a fair spirit, as is evident from this week's sales of Cubas for March-April shipment, which are estimated at 50,000 tons, and may have even reached a higher figure.

The final settlement of the Canadian tariff has caused a renewal of demand from Montreal refiners, one of whom has bought non-privileged sugars at a considerable premium over our spot market in order to secure ready supplies.

Under the tariff, as adopted, the preferential rates continue to be applicable to sugars imported from British possessions through U. S. ports. The preferential rates for basis 96° have been reduced from .550c. to .525c. per pound, while the non-preferential rates remain at .835c. per pound. This increases the preference enjoyed by British possessions' sugars to .31c. per pound, as against .285c. formerly.

A novel feature in the bill is the permission given to domestic feet factories to import raw beet sugar at the preferential tariff rate, in the proportion of two pounds for every pound of refined sugar they produce from Canadian grown beets. The object of this is to enable such factories to run for six months in the year instead of only two months as at present. This change may lead to importations of from 15,000 to 20,000 tons European beets annually.

NOTES.

Raising Seedling Canes in Java.—The following is an abstract of a paper by Dr. J. D. Kobus in the *Archief voor de Java Suikerindustrie,* 1907, No. 1:

The series of experiments described was carried out in order to ascertain whether cane plants, propagated asexually by cuttings and chemically selected for their richness in sugar, would transmit this richness to their offspring when propagated by seeds.

The varieties chosen for experiment were the well known Java cane, Cheribon, and the East Indian cane, Chunnee. From the fact that the Cheribon bears normal ovaries but has infertile pollen, while the Chunnee has fertile pollen, these two canes have been the parents of most of the Javanese seedlings.

In 1904, by chemical selection, plants of both Cheribon and Chunnee canes were found which were rich in sugar, and others poor in sugar. In one part of the experimental grounds a number of furrows were alternately planted with poor Cheribon and poor Chunnee. In another part of the grounds cuttings of rich plants of both kinds were alternated in the same way. These two lots were separated from all other canes by the tall-growing cane L. 3, which does not arrow.

In 1905, the experimental canes arrowed well and produced much seed. The seed (from the Cheribon arrows) was sown, and over a thousand seedlings of each of the two crosses (poor Cheribon by poor Chunnee, and rich Cheribon by rich Chunnee) were planted out in alternate rows, in separate plots, of (two or) four rows each, in order to eliminate the effects of differences of soil.

No difference was visible to the eye in the growth of the offspring of rich or poor plants. In July, 1906, when they were about thirteen and a half months old, they were all cut, plant by plant, and the juice of each of the 2,600 was analyzed. When the average weight of cane and percentage of available sugar of the seedlings of poor parents and of rich parents in each of the thirty-eight plots of four rows each are calculated, the following interesting results are obtained:

Among the thirty-eight corresponding pairs there were only seven occasions on which the seedlings from rich plants contained less sugar than those from poor plants, and the same number on which the former weighed less. Almost always the rows of the rich group produced more and richer canes than the juxtaposed rows of the progeny of poor canes in the same plot.

When the analyses of individual plants are arranged in order of richness in available sugar, it is found that there are many more rich plants among the descendants of the rich group than among the descendants of the poor group. With percentages from 14 on to 20, the seedlings of the rich canes are always in greater numbers, especially in the highest percentages. The average percentage of available sugar in all the 1,300 seedlings from rich canes is 11.77; that of all the 1,300 seedlings from poor canes is 10.89.

If all the 2,600 plants of the two groups are arranged in order of weight of cane, the following results are obtained: Plants lighter than 6 kilograms make up 40.7 per cent. of the poor group, and only 26.9 per cent. of the rich group. Between 6 and 9 kilograms, the numbers are the same. Above 9 kilograms, the seedlings of the rich group preponderate fairly regularly. Above 25 kilograms, there are seventeen of the rich and only six of the poor. The average weight of the rich group is 9.32 kilograms, that of the poor group only 7.69. Since the average percentages of sugar in rich and poor are as 11.77 to 10.89, the total amounts of sugar produced are as 131 to 100, which shows a marked advantage on the side of seedlings from the plants rich in sugar.

Plants over 20 kilograms in weight have in the rich group 13.48 per cent. of sugar, and in the poor group 12.39 per cent. Considering, on the other hand, the richest of the plants in both groups, viz., with 17 to 20 per cent. of sugar, they are each, on the average, about one and a half times as heavy in the rich as in the poor group. This is a much greater difference than was calculated above from the average of all the plants.

The most conspicuous difference, however, is that there are in the rich group 100 individuals with over 17 per cent. available sugar, as against only thirty-three in the poor group. The chance of producing such rich offspring is three times as great with seedlings from rich canes as with seedlings from poor canes. It can therefore be anticipated that, by selecting the canes chemically before crossing, improved varieties can be raised more quickly than in the past.

SUGAR IN CHINA.—The report o fthe Swatow (Eastern Kangtung) Chamber of Commerce upon the local sugar industry, is as follows:

The cane is cultivated in detached plots all over the country, and so it is difficult to make an accurate estimate of the production, but judging from the amount exported the area under cultivation must be about 150,000 mow.

The sugar cane is planted between the first and the third month of the Chinese Year, and matures in ten months. For the first year the crop is raised from cutting; and in the second and third years the root, left after the cane has been cut, is banked over and allowed to spring again. In the fourth year the roots are dug out, and some other crop planted. The cuttings are steeped in water for three days and then put in, covered with sand or straw and watered every day, until they take root. The rows of cane are planted with intervals of a Chinese foot between them, and so closely are the canes set that when they become large the sun cannot reach them. The cane grows in bunches of five or six, a mow being planted with from 1100 to 1200 of these bunches. Beancake is used almost exclusively as fertilizer and costs on the level and good ground Tls. 7 a mow, and among the hills, on poor ground, Tls. 9 a mow.

It takes about fifty-five bunches of stalks (vid. sup.) to produce a hundred catties weight of juice, and the yield of sugar refined is about 700 catties to the mow.

There were about 2000 native mill refineries at work last year, turning out from 1000 to 600 catties of sugar each. Some of these purchased cane and sold the product on their own account, while others were rented by villagers who disposed of their own sugar. The work in the refineries averaged one hundred days. The average number of men to a refinery was twenty-five. These were paid at the rate of 350 cash a day, if they took part in both, the work of the mill and the carrying, and got about one hundred and the cash if they carried alone. The carrying was, of course, to the mill from the plantation. The fuel used in the sugar boiling is the cane refuse, after the sap has been crushed out.

The price of cane has fallen steadily during the last few years. Two years ago a mow produced about $38 most, and last year the yield only realized $21.

The latest prices of sugar ranged from $8.80 to $7 according to quality, with $6.50 to $5 for the residue of treacle in the filters.

Prices some time ago were so low as to leave a very small margin of profit, if any at all.

The above report is issued in response to inquiries made with a view to the reorganization of the whole industry.—From the North China Daily News.

JAPAN.—Hitherto the work of improving methods of sugar manufacture in this country has been carried on only in Formosa and Olinawa (Linkiu Islands). Recently the authorities decided to extend the work to Kagushima prefecture (Southern Kinshu), at the same time introducing some reformation in the official system of the Sugar Manufacture Improvement Affairs Bureau and increasing the number of its personnel.—From the Japan Times.

FORMOSA.—The new Civil Governor of Formosa, Mr. T. Iwai, speaking to the Yiyu Tsushin, says that Formosa may now claim to be a self-supporting colony. Under Chinese control about 12 years ago, the annual revenue of the island was 4 to 5 millions of yen, whereas two years ago the revenue reached the sum of 30 millions of yen, namely over seven or eight times the revenue under Chinese control. Regarding trade during the Chinese regime the total figures were only 20 millions of yen, now it is over 48 millions. We have spent about 140,000,000 yen for the advancement of the island along various lines, since we came into possession, but for two years the island has been able to support herself without any help from the home government. But we must make more preparations for the improvement of sanitary arrangements, docks, harbors and the opening of roads. In a word, to develop Formosa to the full extent of its real value, we must import more capital and skill. Baron Goto's contemplated plan there, is an irrigation scheme for which capital up to 160,000,000 yen is needed for a work of 10 years. When the plan is completed, the revenue of Formosa will become enormous.

The yearly rice crop under the present system is stated to be four million koku, and it will be double under the new management. Estimating one koku at ten yen, we shall have an income of some 80 million yen for rice alone. As for sugar, the present annual production of one million piculs will be trebled. From rice and sugar alone, Formosa will have an income of 100,000,000 yen. There is the camphor industry of about 5,000,000 yen and tea industry to the amount of 6,000,000 yen. When once the work of scientific irrigation is taken up seriously, we can simultaneously apply the water itself in the production of power for industrial purposes. As Formosa is short of coal, we can use this water power for several industries, such as sugar refining, hemp manufacturing, gum and paper mills. By that time Formosa will not only remain a prosperous agricultural country, but will become a very promising industrial island. At any rate, in the next parliament we are contemplating bringing in a bill for an appropriation for a portion of the irrigation project.—From the Japan Times.

CANADA.—A special committee of the House of Commons, which has made an exhaustive investigation into the lumber conditions in wstern prvinces, reports:

Owing to the difficulty of receiving white labor for the mining camps of the Atlin district of British Columbia, Japanese from Vancouver are being hired at $4 per day. Ores rivelling in character those of cobalt are said to have been discovered at Larder Lake, British Columbia.—From the London Times.

DR. MAXWELL AND THE SUGAR GROWERS.—After considerable delay, possibly to give himself ample time to think out the situation, Mr. Maxwell has replied to the letter sent to him some weeks ago by the Sugar Growers' Emigration League, in which they asked his advice as to the best country to make for, should the trend of affairs in Queensland make it impossible for them to carry on. This report may have been mere "bluff" or it may have been prompted by an earnest desire to find an opening for their industry in the event of things "going wrong" in North Queensland—a contingency that was and still is more than possible. The Comptroller emphasizes the reasonableness of the League's position by the significant admission that "we accept the conclusion that the sugar industry in the North will not be kept alive by the wages paid to white labor." And he lays further stress upon the hopelessness of the situation when he continues: "I am fully persuaded of that, and I believe you are equally persuaded. Bear in mind, I do not say the industry in its present volume will be maintained by any force of white production." Is straighter talk needed? Apparently in the estimation of Dr. Maxwell, the sugar industry in North Queensland is doomed to diminish, perhaps to extinction. And judging from his reply to the growers, he is of opinion that it is useless to attmept to import white labor to carry over the coming season. If it is only for one more crop that you are to provide, then you might as well give the business up now. "But he seems to think that there is one hope of salvation for the Northern growers." The * * * most vital question, therefore, is what are the present owners of land and cane growers going to do in order to try to tie imported laborers to the land so that they become settlers? Unless these laborers are turned into settlers, the problem of the present cane farmers will be no nearer solution and unles those imported immigrants are tied to the lands of Queensland they will go further South and the States of the South will be receiving population at the cost of the States of Queensland. This matter of thicker settlement upon our sugar lands will govern the position of the present cane growers in the future, and it will determine whether the industry in the North is to go or to stop. Thus does the Comptroller act the part of Job's comforter to a body of settlers who have borne the brunt of the pioneering of tropical Queensland and are threatened with the extinction of the industry to which they have given the best part of their lives. Mr. Maxwell disclaims any intention of dealing with the matter "from the position of current politics" and incidently proceeds to treat it strictly on political lines, advising the growers never to lose sight of the fact that the transference to the Commonwealth of what once were the powers of the State has changed their position considerably and asks, have the Northern sugar growers anything like a guarantee, that the nature of their industry and its special demands will be understood and adequately legislated for by the federal parliament, five-sixths of whose members live in and represent conditions which are totatlly different from the conditions of their life and business. As an assistance in the direction of relief, Dr. Maxwell's reply is so much waste matter, although he does give a broad hint that the United States Government would welcome just such settlers as our Northern sugar men to take up land in the Hawaiian Islands. As a clear statement of the position and the hopelessness of the outlook, however, it hits the nail right on the head and amply justifies the anxiety of the Northern growers to find fresh fields and pastures new, for it is evident that tropical agriculture in Australia is never destined to succeed until the colored race of the world have died out and thus removed the competition which renders it impossible for Australians to produce anything beyond the requirements of the Commonwealth that is produced in other countries of the world by cheap labor and that only by the forbearance of the majority of the population in submitting to pay higher rate for said products in order that Australia may be "all white." So far as that majority is concerned its units have little to trouble them in the way of colored labor competition. But what would happen should India, for instance, develop a large butter export trade? Where would Victoria be then? Of South Australia, if Egypt by the extension of irrigation were to produce a large surplus of wheat for export? Queensland might look for more Southern sympathy then, and it might not be necessary for North Queensland to contemplate emigration.—*Queenslander.*

AGRICULTURE SHOULD BE TAUGHT IN CUBAN SCHOOLS.—In the "Reivsta de la falultad de Letras y liencias," the organ of the University of Havana, we find a very suggestive article on the urgent need for some instruction in the rudiments of agriculture in the public country schools of Cuba. The author, Professor Jose Cadenas, not only makes a strong plea for the introduction of this industry, but gives simple directions, with illustrations, showing how easily it would be managed with no expensixe change in the present system. He says that it seems to him of more importance that a child should have some general fundamental ideas about the nature of soils and conditions of vegetable life than about countries which he never will see. The future of Cuba is agricultural, and no efforts should be spared to put her in the way of competing successfully with scientifically trained rivals.—From the Cuba Review.

RICE AND SUGAR CROPS IN INDIA.—The Government of British India announces that the rice crop for 1906-7 of that country, excluding Lower Burma (which has a rice area of 9.7 per cent. of the total), is estimated at 368,334,000 hundredweight (of 112 pounds each), a decrease of 1.8 per cent. from the previous year.

The six provinces, producing 96.5 per cent. of the sugar cane crop, report 2,348,800 acres, an increase of 11.2 per cent., and a total outturn of 2,223,400 tons (of 2,240 pounds each) of unrefined sugar, the increase being 28.9 per cent.

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*MECHANICAL FORCED FEEDING OF INTERMEDIATE AND FINAL CANE MILLS.**

BY JAMES M. STEEL, *Sugar Engineer and Expert.*

The high efficiency attained by the crushing plants of nine, and more recently of twelve rollers, in these Islands, leaves but a limited margin of loss in grinding, of which the prevention may be regarded as practicable or profitable.

Savings are now more to be looked for, (1) in keeping the work uniformly good by preventing the lapses which from time to time occur in the uniformity of the feed, and in the gripping effect of the rollers in carrying it through. (2) In reducing the time lost in stoppages for repairs to accessories such as conveyers and juice screens, etc. In these ways the savings to be effected are in reality greater than would appear in percentage upon the actual quantity of cane dealt with, the

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* Read before the Hawaiian Engineering Association.

saving of time being of almost as great importance and value as the saving in percentage of sugar.

The step now to be taken to effect these improvements, is the adoption or resumption of forced feeding.

The special form of feeder which I have to propose would be applicable to the arrangements of Apron Conveyor now in general use, and may also be made the occasion of adopting a much simpler and more effective type of conveyor, subject to much less wear and tear and much less liable to break down.

The principal of forced feeding is not new. In my own experience it is a matter of 17 or 18 years since I had first to do with its adoption, and I suppose (although without my knowledge) it may have been in use at an earlier date.

Some years ago, in these Islands, when two-roller mills were much in use for the final crushing of the bagasse, a mechanical feeder was found to be essential to their satisfactory working. For this purpose, two types were in use, one being Young's Feeder and the other the Riley Pusher.

Young's Feeder cannot be described as a "Forced Feeder," but rather as an induced feeder, its action being to throw up the bagasse in front of the rollers and so induce the feed. The Riley, on the other hand, is a forced feeder proper, its action being to thrust the bagasse between the rollers and so force the feed.

Since the adoption of nine roller mills, placed compactly together and driven by one train of gearing and engine, the practice of using mechanical feeders has fallen into desuetude and appears to have been quite lost sight of. This appears to have been due, among other causes, to the arrangement and type of apron conveyor which has been adopted in compacting the plant, and which, while it precluded the application of the types of feeders hitherto in use, seemed necessary with the close arrangement of the different sets of rollers.

Regarding the faults which it is proposed to remedy by means of forced feeding, I would say:

With the apron conveyors as at present arranged there is no feed plate, the bagasse being deposited directly on the top of the front roller by the apron, which turns over a small axis as close as possible to the top of the roller. In the nature of things the apron cannot be expected to exert any force to push the bagasse between the rollers. The feeding of the mill entirely depends upon the surface condition and setting of the rollers and upon the toughness and length of the fiber of the bagasse.

In his paper on "Mill Settings," read before this Association last year, Mr. Keech argued that it was quite practicable to have the rollers of a three-roller mill so set that the downward thrust of the top roller would be more or less equally divided between the two bottom ones.

Now it is obvious that where no extraneous means are used to force or compel the feeding, the amount of bagasse which will be drawn in by the mill, with any given setting, will be to a large extent dependent upon the surface condition of the front and top rollers. At the beginning of the season, when the rollers are freshly turned and the grooving sharp, it will be possible to take in a heavier feed, with the same setting and surface speed, than later on when the surfaces have become worn comparatively smooth. It will then become necessary to adopt a wider setting of the front roller to get the same feed through. It is a fact that with a soft roller the tendency is to retain and even improve its roughness by the wear to which it is subjected. Nevertheless, this quality is not general in rollers, and is not without its disadvantages.

A soft roller is subject to rapid and irregular wear, generally heaviest towards the center. This results in the roller becoming concave; it may be touching at the ends, while showing an opening at the middle. Owing to this rapid wear and the considerable wastage in turning up true and regrooving, a soft roller has but a short life.

Assuming, therefore, that after a period of service the rollers have become to a degree worn smooth and it becomes necessary to adopt a wider setting of the front roller, this will of necessity be accompanied by a diminution of the pressure upon it, thus disturbing the balance between the pressures upon the front and back rollers, respectively, which may have at first existed. Now, with a system of forced feeding, which would control the amount of the feed independently of the condition of the rollers, the original setting and consequently the original balance of the pressures could be maintained.

It certainly cannot be regarded as satisfactory to simply deposit the feed upon the top of the front roller and then leave it to the good will of the mill or any fortuitous conditions, as to how much will go through with a particular setting. We ought to have as much going through as the strength of the mill and the amount of available driving power will justify, and we ought to know that at any and all times, that amount is going through. In other words, the setting of the mill should be determined in proportion to its strength and driving power, and not by the consideration of the smoothness or roughness of the rollers.

Although not at present occupied with mill work, the writer has had in the past some experience of successful mechanical feeding of mills, and so has confidence in the attainment of the best conditions by its means.

Generally where forced feeders are in use the arrangement of the conveyor is different from that in use here with the nine and twelve-roller mills. The bagasse is delivered at a point considerable above the front roller and falls upon a feed table, from which it is thrust between the rollers by the pushing plate of the feeding appliance. This arrangement of conveyor suits for the ordinary form of Riley pusher, or indeed for any other, but is not readily applicable where the sets of rollers are so close together as in the nine-roller St. Louis mill. With these close-set mills the steepness of an apron conveyor would have to be such as to make it doubtful whether the bagasse could be carried up on it without slipping and falling back.

The feeder about to be described is intended to be applicable to any arrangement and form of conveyor. It essentially consists of a swinging pusher plate, so pivoted that the edge of the plate reciprocates in a line approximately tangential to the top and front rollers.

Figure 1 is a diagram of the arrangement to work with the ordinary apron conveyor.

Figure 2 shows the arrangement with an overhead conveyor of special design.

As will be observed by reference to the diagrams, the pusher plate is curved to the radius at which it swings, and is actuated by means of short connecting rods, from a crank shaft, or through the latter by rocking arms, the crank shaft being placed over head, and in its turn driven by a belt and pulleys from the engine shaft. In the first arrangement with the ordinary apron conveyor, the pusher plate is suspended above the feed and strikes down and inward, thrusting it between the rollers. In the second arrangement it forms a sort of swinging hopper from which the feed falls upon the top roller, to be thrust between the rollers by its edge as it swings. In the second arrangement there is shown a fixed retention plate with a serrated edge next the roller, under the pusher, fitted close to the front roller. The object of this is to intercept any bagasse which may be carried down with the flowing juice.

Generally speaking, the advantages of this type of feeder are (a) that all the moving joints are away from the juice and easily lubricated, (b) there are no rubbing surfaces, and consequently the least possible amount of wear and corrosion. In the second arrangement the feed is effectually confined, and with either arrangement the action is a positive one and the mill cannot choke and refuse.

The speed at which a feeder should be driven cannot well be determined except by experience. In practice it has been found that a feeder making 50 to 60 strokes per minute will give good results.

With regard to the conveyor shown in Diagram 2, it may be pointed out that it has considerable advantages over the

FIGURE II.

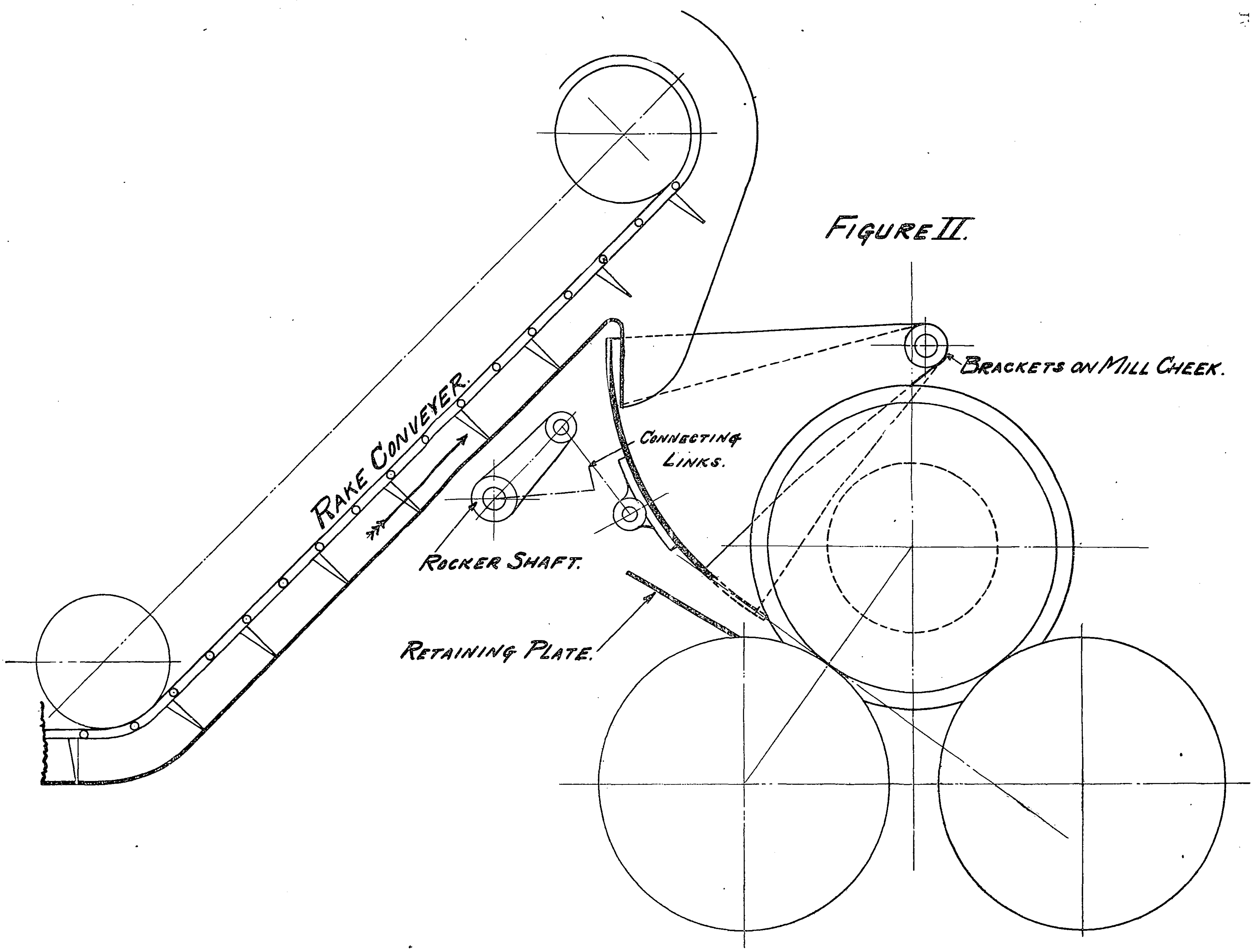
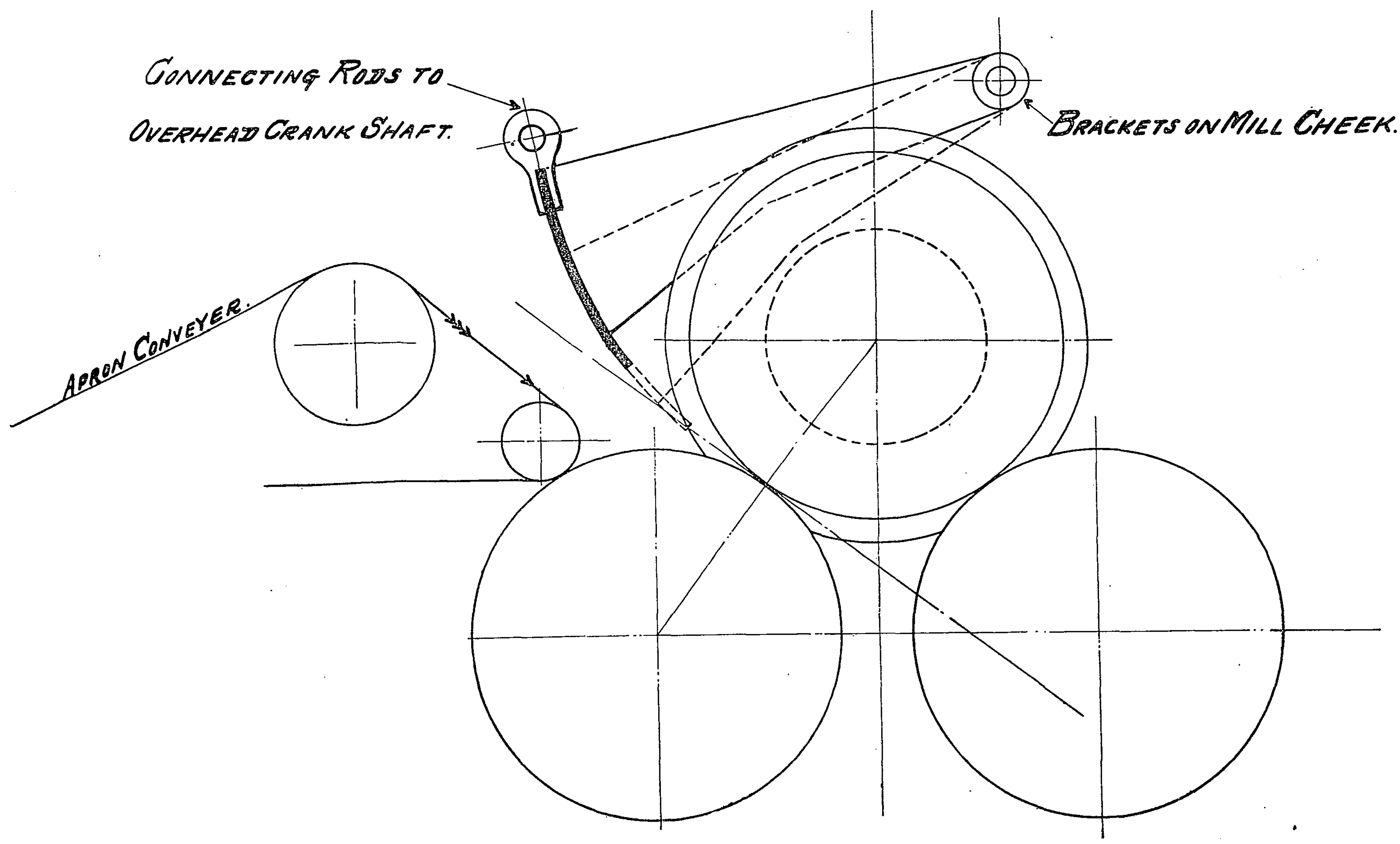


FIGURE I.



ordinary apron conveyor. (1) These are of light, thin material, with a great many pieces and working joints, which, being constantly bathed in juice and maceration water, are subject to rapid corrosion and wear. (2) As the apron, although returning close to the top of the roller, has to clear it, there is a space between it and the roller through which quantities of the smaller particles of bagasse are washed down and carried away by the expressed juice, making heavy work for the juice screens. This is augmented by the scraping action of the aprons themselves, carrying down bagasse in addition to that carried down by the juice. (3) In turning over the small axis above the roller, the spaces between the slats open out, allowing pieces of bagasse to drop through into the interior of the apron, and these, as they accumulate, have to be removed by hand. In an improved construction by Mr. Ginaca this latter objection is overcome by making the slats of a section which admits of sufficient lap, and a stiff support, so that no opening is presented in turning over the small axis.

The type of conveyor shown in Diagram 2 does away with almost all the objections enumerated. It consists of a flat trough, set at the required angle. In it are mounted two or more, long link pitch chains, running over suitable sprockets, and carrying at intervals light iron racks. In this conveyor the bagasse rests upon the bottom of the trough and is carried up by the rakes to the delivery end. The advantages of this arrangement are: (1) There are comparatively few moving parts and working joints, and only a limited surface of moving parts exposed to the corrosive action of the juice. (2) The conveyor is perfectly water-tight, and, no matter how much maceration water may be used, there is no leaking or dripping from it. (3) The whole of the surface over which the bagasse is carried is fixed, and may be constructed of sheets thick enough to make ample allowance for wear and corrosion.

Regarding the arrangement of swinging feeder shown with this type of conveyor, it consists of a curved plate, as shown. It is carried on cheek plates, which preferably would be formed by simply cutting the plate long enough and bending up the ends. These are pivoted at such a point that the line of motion of the pushing edge is tangential, approximately, to the top and front rollers. This plate forms a swinging hopper, as before mentioned, into which the bagasse is delivered by the conveyor and from which it falls upon the front roller, and is thrust between the rollers by the edge of the plate. The feeder may be driven through connecting links, by the arms of a rocker shaft, as shown; this in its turn is driven by a revolving crank shaft and belt pulley from the main shaft of the engine. Beneath the pusher is the fixed feed plate with serrated edge, already referred to.

The object of the foregoing is not so much to advocate a particular form of feeder, as to draw attention to the whole subject of the forced feeding of cane mills, and bringing out expressions of opinion and discussion upon it.

PROGRESS IN PLANT BREEDING.

In agricultural science there is probably no line of investigation that is receiving more attention than the improvement of plants by expert methods of selection and breeding. It is only in comparatively recent years that it was ascertained that sugar cane produces fertile seeds and that the field was open to obtain improved varieties as to richness of juice and with disease resistent characteristics.

A discussion of this subject and the results of the experiments carried on along these lines by the sugar experiment stations of the world are well set out in a recent paper by Sir Daniel Morris, Imperial Commissioner of Agriculture for the West Indies and F. A. Stockdale of the same department, entitled "The Improvement of the Sugar Cane by Selection and Hybridization," which we take pleasure in republishing.

Very interesting and successful experiments in plant breeding have been carried on in other agricultural lines, and recently a number of the Experiment Stations of the United States have issued bulletins dealing with the results obtained in breeding as relating to the special lines of investigation in hand.

One of the most interesting of these is that from the Maine Agricultural Station which briefly epitomizes the history of plant breeding as applied to American fruits; the preface of the bulletin dealing with the beginning of systematic breeding is interesting and is as follows:

"The whole question of plant and animal breeding is in a state of transition, for, with a sudden interest in Mendel's work, and the generalizations of De Vries and others, investigations in breeding are taking a new direction, not necessarily less practical in final results, but at present less comprehensible to the average man. It has therefore seemed worth while to give a brief statement of methods heretofore employed in plant breeding, in their relation to the development of American fruits, and a summary of the results already accomplished.

"The breeding of plants, as of animals, is quite as much a question of culture, care and selection, as it is the production of a departure from a given type. Most plants live an indifferent existence, dependent very closely upon immediate conditions of environment. Furthermore, every part of a plant lives largely for itself and is capable of propagating and multiplying itself if removed from the parent plant. This fact increases the importance of suitable environment, and of a knowledge of methods of propagation on the part of one who is to undertake systematic breeding. In the study of plant breeding then, for all practical purposes, the unit is the embryo individual plant, whether in the form of a seed or a bud. While in the light of recent investigations this statement may be regarded as somewhat antiquated, the writer would still maintain the position that in the prosecution of the practical improvement of the American fruits, this proposition will hold. Of course in the scientific investigation of the principles of plant breeding, embryological conditions are of importance.

In recent times the student of plant breeding thinks that he has a key to the laws of plant variation in the so-called "Mendel's Law," and there are many facts which tend to strengthen that belief, but a discussion of that subject is not intended at this time.

BEGINNING A SYSTEMATIC BREEDING OF FRUITS.

"One of the most significant facts in nature is that every species of plant which man has cultivated for any length of time has numerous forms, varieties, or strains. The practical horticulturist selects that form or strain which is best for certain purposes or for certain conditions. The plant breeder asks why or how these forms came about and how they can be improved. It is worthy of note, however, that until about a century ago the principal studies of plant life were made from wild forms rather than from domesticated species.

THE WORK OF VAN MONS.

"The man who first propounded a theory of the philosophy of the origin of varieties of cultivated plants, was Jean Baptiste Van Mons, who was born in Brussels, in 1765, and died in 1842. Van Mons was by profession a chemist, and horticulture was his avocation. His theory applied particularly to fruit trees, but he held that the principles he set forth are of general application in the vegetable kingdom.

"Van Mons 'theory may be briefly epitomized as follows: All fine fruits are artificial products. There is always a tendency in all varieties of fruit trees to return, by their seeds, towards a wild state. This tendency is most strongly shown in the seeds borne by old fruit trees. On the other hand, the seeds of a young fruit tree of a good sort, being itself in a state of amelioration, have the least tendency to retrograde, and are most likely to produce improved sorts. Finally, there is a limit to perfection in fruits. When this point is reached, as in the finest varieties, the next generation will more probably produce poorer fruits than if reared from seeds of an indifferent variety in the course of amelioration.

"This system or theory was not founded upon experience or practice, but was a preconceived idea of the author, who spent fifty years, with all the zeal of an enthusiast, in an attempt to prove his theory. He began his work by gathering seeds from a young seedling tree without paying much attention to its quality except that it must be in a state of variation. The seedlings were planted closely in nursery rows and often checked by pruning, with the thought that to improve the fruit the original rank growth of the tree must be subdued or enfeebled. From the first fruits produced, and the fruit was always gathered before it was fully ripened, seeds were saved and sown again; and this practice was continued generation after generation. The whole process was, to use his own words: "To sow, to re-sow, to sow again, to sow perpetually; in short to do nothing but sow is the practice to be pursued and which cannot be departed from." Van Mons' work, which was largely confined to pears, was begun in 1785. Thirty years later, in 1823, when he had commenced distributing scions freely throughout the world, he had 80,000 seedling trees in his nursery. At this time his first catalogue was issued and in it 1050 pears are mentioned by name or number. Of this list 405 were his own creation and 200 of them had been considered worthy of naming, among them being some of the varieties which are still raised the world over, including Diel, Bosc, Colmar, Manning's Elizabeth, and many others of equal merit. Many of these varieties found their way into America, chiefly through the efforts of Robert Manning of Massachusetts.

"Whatever may be thought as to his theories, there is no doubt that Van Mons accomplished more than any other single individual up to the middle of the nineteenth century in breeding new and valuable fruits. Without discussing the principles for the establishment of which Van Mons was working, it is enough to say that in some of his series the generations came into bearing earlier and earlier until in the fifth generations of certain pears, he was able to secure fruit at 3 years from seed. As already intimated, however, this was at least partly brought about by the system of enfeebling and consequent encouragement of the habits of precocity, and by cumulative selection. Probably no worker with plants has ever given to the world so clear a demonstration of the value of selection as Van Mons; and this demonstration is worth all of the efforts put forth, even though this was made in the attempt to prove another and, as is now believed, erroneous doctrine.

WORK OF THOMAS ANDREW KNIGHT.

"Contemporaneous with Van Mons, was Thomas Andrew Knight, often referred to as the father of modern horticulture; a man whose work as a careful, accurate, scientific investigator of the phenomena of plant life, especially in its economic relations, is unrivaled even at the present time, and whose opinions upon the studies of crossing and of plant developmpent were of the utmost importance. Knight was born in England in 1759 and died in 1838. His investigations of problems in physiological botany have become classic and he brought the same energy and thoroughness to his investigations of horticultural problems. He gave particular attention to the physiology and methods of root grafting,* but his greatest work was in the direction of the improvement of cultivated plants, by breeding. He took up the question of the running out of varieties and made great efforts to produce new ones. He was confronted by the same problems which appealed to Van Mons, but he approached the subject in a very different way. Knight asked direct questions of nature, and never arrived at a general theory of the improvement of plants, although he was not without hypotheses concerning the phenomena he was studying.

"Van Mons, as noted, was the first to demonstrate the importance of selection in the improvement of plants; Knight was the first to show the value of crossing for the same purpose. As early as 1806 he wrote: "New varieties of species of fruit will generally be better obtained by introducing the farina of one variety of fruit into the blossoms of another, than by propagating any from a single kind." The varieties which he raised, largely by means of crossing, included apples, pears, plums, peaches, cherries and strawberries, as well as many vegetables such as potatoes, peas, cabbages and others; but more important than the new fruits, which were of immediate and so-called practical value, was the contribution to the general knowledge of plant life, and of the methods to be employed in amelioration, which Knight gave freely for the benefit of all mankind.

"Such, in brief, are the beginnings of the science of plant breeding, as exemplified in the amelioration of domesticated fruits. Early in the nineteenth century the more advanced

* See Transactions of London Horticultural Society.

† Ibid. Vol. 1, p. 38, 1896.

horticulturists were awakening to the fact that plants as well as animals are capable of improvement by systematic breeding. As the years have gone on, knowledge of the factors involved, and of methods of procedure, has increased, with the result that a new horticulture has developed in this country. European varieties and European methods of culture have been superseded by varieties and methods of American origin,—varieties and methods better suited to the very different climatic conditions and to popular demands.

SOME UNSOLVED PROBLEMS.

"Each year marks a great advance in the work done in plant breeding. The work carried on by the United States Department of Agriculture, under the immediate direction of Dr. Webber, is of inestimable value; and the "new creations" in fruits and flowers which periodically appear in the garden of Luther Burbank at Santa Rosa, California, have attracted world wide attention. But the mere production of new forms of intrinsic value is not the only work in hand. It is now coming to be recognized that many diseases of plants are due to some, often times it may be slight, lack of adaptation to conditions and surroundings. The plants are "out of tune" with their environment, and this lack of adaptation, though slight, may make the difference between profit and loss in the returns from a given crop. The disease known as *couloure*, or the falling of the flowers and young fruit of certain of the finest raisin grapes in California is a case in point. An investigation by officers of the Department of Agriculture has shown that this trouble is mainly due to unfavorable climatic conditions at the time of blooming. If, now, the time of blooming should be delayed somewhat until the season of settled weather, or if the varieties should be rendered slightly hardier, so as to resist the unfavorable conditions, a service of untold benefit would be rendered to the raisin industry of California. In the attempt to meet the emergency, some 20 thousand crosses have been made between the two best raisin grapes—Muscat of Alexandria and Muscatel Gordo Blanco—with the Malaga, a vigorous, hardy, thrifty sort which, though an excellent raisin grape, is inferior to the sorts named.* As the seedlings resulting from these cyrosses come into fruitage the hardiest and most resistant types will be selected in the hope of securing the desired end.

"A similar problem confronts the growers of citrus fruits in Florida and Louisiana,—a fact again emphasized by the recent severe losses from freezing. Here, again, the Department of Agriculture is doing an important work in crossing the more

* Yearbook, U. S. Dept. of Agriculture, 1898, 265.

valuable varieties of the orange with the *Citrus trifoliata*, which is hardy as far north as Philadelphia. Several hundred hybrids have been produced and are now growing; many of them showing varieties intermediate in character. Of course the end in view is to secure, by a sufficient number of crosses, a variety which shall combine the good qualities of the common orange with the hardiness of the trifoliate parent. The same method may be looked to in the production of hardier varieties of other subtropical fruits.

"Another problem in citrus culture is the production of an orange with the skin of a tangerine. Hybrid seedlings to the number of a thousand or more have been produced, and results are awaited with interest. The breeding of pineapples of superior quality, and resistant to disease, is also receiving special attention in the subtropical laboratory of the Bureau of Plant Industry, the crosses of this fruit running up into the thousands.

"In pear growing it is very important to combine the disease resisting qualities of the Oriental varieties with the highest quality of fruit of the European sorts. Some hundreds of crosses have been made with this in view.

"In plum culture, especially in northern New England, the same problem is met. In former years plum growing was an extensive industry in the Penobscot valley, but the dreaded black knot drove the industry out of the country. Is it possible, by crossing with the Japanese varieties, which seem less subject to the attack of this disease, to produce sorts which, while resistant to disease, shall be hardy enough to resist the severe winter?

"Cherries also, in years past, have formed an important item in the income of fruit growers along the Kennebec. But the demand for sour cherries in the Boston markets is limited, and the hearts and biggarreaus are very uncertain in point of hardiness. Most of the cherries for which Hallowell and Gardiner have been locally noted in the past, were seedlings of Black Tartarian. But these seedlings are very uncertain and are frequently killed back by severe winters. With a view to combining the vigor and hardiness of the sour cherries with the good qualities of the fruit of the sweet sorts, Card of Rhode Island, has made numerous crosses. A large proportion of the sour cherries crossed by the sweet varieties matured fruit which apparently was normal. Curiously enough, however, the reciprocal crosses in every instance failed to mature fruit,* and in a personal letter to the writer, Professor Card writes that in only two instances was he able to secure germination from the crosses made—and these seedlings met with an accident and were lost.

*Rpt. R. I. Sept Station 1899. 130

"Apples, quinces, peaches and the various small fruits, are all, without doubt, capable of producing disease resisting forms which shall do away, in a measure at least, with the expense and labor of spraying and otherwise combating the numerous fungous pests with which the orchardist must contend.

"While the reigning types of native fruits are the result, largely, of the force of circumstances rather than the direct choice of man, an intelligent choice of species and of forms has, nevertheless, played an important part in the evolution of these types, and it may play a still more important part in the years to come.

"As suggested at the beginning of this discussion, plant breeding in its relation to pomology has as yet been largely fortuitous. Little study of fundamental laws has been made. Thousands of crosses have been made and hundreds of thousands of seedlings have been produced, but the work has been largely without definite ideals in view, and without a view of probable means of reaching an ideal. In the judgment of the writer, the problems of propagation, environment, and individual variation are of quite as much importance, and are certainly as little understood as are the obscure problems of cytological variations and combinations.

"Many years ago Thomas Andrew Knight popularized the method of root grafting, and the question of the mutual influence of scion and stock has long been a fertile one for discussion. Nevertheless little accurate work has been done in studying the problems thus involved.

"It is known, in a general way, that certain chemicals have specific effects upon the color, composition or other characteristics of fruits, but accurate data in this direction are scarce. The fact of individuality in fruit plants is recognized, but its importance as a factor in the development of a type has been almost wholly overlooked.

"The fact of the existence of graft hybrids is freely maintained, but the principles involved in the production of such forms remain a closed book.

"In the past most discussions of pomological problems have been empirical. There are certain principles underlying the subject, however, which, in common with the improvement of plants in general, are fundamental and far reaching in their importance. It is to this class of problems, more scientific but not less practical in their nature, that pomologists and plant breeders alike are devoting thought and study at the present time. The solution of some of these problems, and the classification of knowledge concerning the subject, is necessary in order to raise pomology to the rank of a distinct science."

The Agricultural Experiment Station of Nebraska has been carrying on experiments looking to the improvement of wheat and other cereals by the selection of desirable varieties, and in its twentieth annual report it is said:

The work of the Experiment Station for the current year has been confined to the following lines, namely:

Improvement of winter wheat by selection of desirable varieties hardy in the northern and western portions of the State, cross-breeding varieties to combine desirable qualities, selection of individual plants, etc. One hundred and forty new strains of wheat, originated in this way, are now being tested under field conditions. A large number of varieties of wheat are being brought from other States to note the effect of climate on quality and yield.

Promising varieties of oats are added each year, to test in comparison with standard varieties of this region.

Improvement of corn is carried on by selecting varieties and by improving the yield of the most promising varieties by the ear-and-row method of selection. About 400 ears are being tested in this way each year in breeding plats, selecting seed from those which prove superior in yield and desirable qualities. A study is being made of qualities which are correlated with large production.

Improvement of alfalfa seed by selection of individual plants is in progress, 3,000 plants in the nursery having been studied the last three years. Seed is being selected from those plants which present the largest number of desirable characteristics.

The "Experiment Station Record" for March, 1907, contains an interesting general discussion of the work outlined by the American Breeders' Association as follows:

Breeding as an art is perhaps as old as agriculture itself; certainly notable results were secured in the early ages. But efforts to put breeding on a scientific basis are very modern. The recent republication of Mendel's discoveries has given a great impetus to the systematic and thorough study of heredity and its practical bearings on animal and plant production, and there is now active and widespread interest in the subject of breeding in its scientific aspects.

In this country the movement is being fostered by the American Breeders' Association, whose purpose is stated in its constitution to be "to study the laws of breeding and to promote the improvement of plants and animals by the development of expert methods of breeding." This association was organized in 1904, and has held four regular meetings which were largely attended by the leading investigators and many practical breeders. The proceedings of the first three meetings have been published in two volumes, and comprise over one hundred and forty addresses and scientific papers relating for the most part to the theory of animal and plant breeding. Taken together, these reports contain the best that is known in breeding, and furnish a basis for the revision of much that is contained in the treatises now used as text-books in the agricultural colleges.

The advantages of such an association in promoting and developing investigation in this important subject are very great. The subject is comparatively new as far as systematic investigation is concerned, and we have need of all the light that can come from associated effort and experience. The association has taken up the subject in a systematic manner, a large number of committees being authorized at the meeting in 1906 to look after various phases of animal and plant breeding. General problems were assigned to thirteen distinct committees, while fifteen others were to undertake the study of special problems relating directly to animal breeding, and a like number the problems of plant breeding. The membership of these committees includes some of the foremost investigators of the country.

Many of these committees have perfected their organization, accomplished considerable work of a preliminary nature, and are now actively engaged upon the duties assigned them, as indicated by the reports of progress presented at the recent meeting.

The present popularity of plant breeding is clearly evidenced by the large number of projects presented for investigation under the Adams fund. These probably exceed in number those proposed in any other single subject, but the wide range and grade of these undertakings indicate some misconceptions as to the research character of some of this work.

These projects may be classified somewhat roughly as follows: (1) Those which aim at "improvement" in a vague and indefinite way; (2) those which propose improvement and adaptation along rather more definite lines, through selections made from the crops in the field by eliminating the poorer groups rather than by isolating the superior individuals; (3) systematic breeding and selection, starting from the individual; (4) development of resistance to disease, insect attacks, hardiness, etc., by selecting individuals wherever found; (5) improvement through crossing and hybridizing, to be followed by systematic and rigorous selection; and (6) investigations into the laws of inheritance and variability, study of the correlations of vegetative parts with certain qualities, etc., to secure a basis for generalizations on the principles of breeding.

These classes evidently differ quite widely from a scientific standpoint and in the contribution they may be expected to make to our knowledge of breeding. The question is, Where should the line be drawn between the work of the plant breeder as an expert and investigator on the one hand and that of the seedsman and nurseryman on the other ? There is a marked tendency among a certain class of men to regard the mere production of things, the general improvement of a plant or an animal in some respect, as research, wholly apart from any plan of adding to what we know about breeding and the laws governing it. These efforts consist in the adaptation of a plant to new environment, improving it in resistance to drought, earliness, productiveness, its composition with respect to some valuable constituent, and various qualities which go to make up excellence. Sometimes the plan does not even go so far as to designate the special line of improvement, and to this extent is aimless; and between this and the more specific and detailed plans of operations there are all gradations. Such work will usually not be along well-defined lines and methods, and unless it is carried out more carefully than the plan is outlined, it can be expected to add nothing of value to our methods.

Desirable as such work may be from a purely practical standpoint, it is difficult to see how it can be regarded as investigation in any true sense, and there is even doubt as to whether it is not more properly the work of seedsmen and nurserymen than of an experiment station. Its real purpose is the attainment of material ends, the finding of something which is better, and it is not undertaken with a view to learning why certain results follow, and whether they are chance occurrences or in accordance with a general law and may serve as a safe basis of procedure. It is argued that we shall learn considerable from such work incidentally, but it seems very doubtful whether a man who is content to start out with a project which avowedly aims only at skillful improvement in an empirical way will often give himself much concern with incidental occurrences, whose study would delay him in his haste to attain a purely utilitarian end. Indeed, it may be questioned whether such work is often undertaken in the true scientific spirit.

It is the man who couples with his plan for improvement the purpose to add something to our knowledge, at least to the extent of knowing exactly how his end was attained, who will observe closely those specimens which do not come up to his requirements, as well as those that do, will study the course of development carefully, and will thus learn something of the limitations and the idiosyncrasies of the supposed laws or rules.

Happily for the development of breeding as a science, a considerable number of projects have been undertaken which deal primarily or in part with the scientific aspects of the case. This is an encouraging tendency, and indicates something of a revolt from routine improvement work. More of the breeding work which now seems to be aimed at results without reference to the factors influencing their origin might be made to contribute toward the working out of certain principles if planned with reference to that end, and it seems extremely desirable that men who are engaged in this improvement work should take this feature into account.

Many have taken up breeding work without adequate preparation for it, and see in it only the possibility of "creating" something useful. Surely if anything more than the manipulative skill of the commercial breeder is claimed for this work, if it is to be regarded as appropriate for a station expert or an investigator, it should be undertaken with a full knowledge of the status of our information, so that advantage may be taken of the progress already made and of the most advanced thought in that field. Only in this way is the breeder equipped to observe intelligently and to correlate his observations in a way to be helpful.

One of the first requisites is accurate observation and the keeping of complete records. It is said that the only record of many new varieties is in the memory of the originator. The mere weeding out of those individuals which do not come up to the ideal standard, without any record as to their prevalence or characteristics, makes the results useless for a study of inheritance and variability; but how important for this purpose might be a study of the reversions and the causes which lead to them.

Certain supposed limitations in plant breeding are so often mentioned that they have become almost axiomatic. Among these are the incompatability of earliness and prolificacy, of large size and number of parts, and the correlation of other qualities. There is opportunity for further observation on these points, and if this limitation is found to prevail, the physiological phenomena which determine this antagonism remain to be worked out. Moreover, the recent work of Bateson has cast a doubt on the limitations of selection as a means of fixing a type which is worthy of further investigation.

The study of mutations, as described by De Vries, seems a fruitful field for investigation. The old taxonomic idea of the fixity of species appears to be doomed to give way to a different concept. MacDougal has recently shown that plants can be so profoundly affected by chemicals as to lose their character sufficiently to result in the production of new forms. If this should be true it may result in a new method of plant breeding, and at all events it calls attention to the possible influence of certain environmental conditions. Fertilizers and soil conditions are known to have an effect on the composition of the plant as well as on the quality. The turnip has been found to be quite constantly influenced in composition in proportion to the deficiency of the soil in phosphoric acid, and in the case of cereals an attempt has been made to work out a method for ascertaining the fertilizer requirements of the soil on the basis of the composition of the crop grown.

The necessity of taking these matters into account when plants are being bred for increased protein, and of fully checking or controlling all conditions other than individuality which may cause changes, will be apparent. In the case of leguminous plants bred for increased protein content the possible effect of nitrogen assimiliation as a disturbing factor should be borne in mind. It has been shown that nitrogen assimilation may have the effect of increasing the nitrogen content of the plant or its seed, and it has also been found that plants apparently vary considerably in the energy with which they assimilate atmospheric nitrogen.

The conditions surrounding this activity and the factors which influence it are little understood, but these differences in conditions or capacity of the plant may nullify the results of breeding work which does not take account of them. The obvious remedy would seem to be the treatment of the soil in which these experiments are made in such way as to eliminate nitrogen assimilation and its attendant influences.

There is every reason why the breeding work as a whole should be placed upon a more scientific basis. It has become a prominent feature of the work of the stations, and the practical results attained have aroused interest and confidence in it. Already attention is being given by the more progressive farmers to selection, the use of improved seed, etc., and the work of the stations and others is therefore finding practical application in their hands. The greatest need of this work is improved methods and a better understanding of the principles involved, in order that observation may be guided and the interpretation of results made more sure.

*THE IMPROVEMENT OF THE SUGAR CANE BY SELECTION AND HYBRIDIZATION.**

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The discovery that the sugar cane produces fertile seed, from which can be raised seedlings possessing varied characteristics as well as increased richness of juice, has placed cane growers in a position to endeavor to improve their varieties, so as to place the cane in an equally favorable position with the beet.

The attacks of various diseases and the general fall in the price of sugar made it necessary for all cane-growing countries to establish local departments to inquire into the best means of combating these disasters. Owing to the great influence of soil and climatic conditions on the yield of sugar, highly improved methods of cultivation and the use of modern appliances in manufacture, received considerable attention, as being the most direct means of accomplishing a cheaper production. It was, however, found that a hardier race of plants, which would give a greater tonnage of canes to the acre, was the first requisite, the quality of the juice being taken up for improvement later.

Although most of the older varieties of canes were found to suffer from the ravages of insects and disease, and, in consequence, a considerable loss of sugar was experienced, yet no serious steps were taken to inquire into the methods of preventing this loss until, in some instances, total crops had been almost entirely destroyed. Then the minds of a few began to turn to methods of obtaining improved varieties of canes. It became absolutely necessary to produce canes which were more resistant to disease, and at the same time if possible, varieties which would give a larger yield of sugar per acre. This increased yield of sugar could be obtained in three ways, the combination of all three being the goal aimed at. These were: (a) by an increased tonnage of canes per acre; (b) by an increased yield of saccha-

*This paper was presented to the Conference on Genetics held in London in August, 1906, under the auspices of the Royal Horticultural Society, and is reprinted from the official report on the Conference.

rose in the juice, and a higher ratiô of purity; (c) by a freedom from rotten canes.

The differences apparent in existing varieties made it obvious that it was possible to produce new and improved types superior to those already under cultivation; but, like all plants propagated mainly by cuttings, it was extremely difficult to notice slight variations amongst individual canes. Striking examples of seminal and bud variations had been noticed and some of these had proved of value. The following four methods were those by which variations were utilized to improve the quality of the crops: (1) Selection amongst native varieties; (2) Introduction of foreign varieties; (3) Hybridization between native varieties; (4) Hybridization between native and introduced varieties.

The first two methods will be dealt with very briefly, as they were carefully described at the Hybridization Conference held in New York in 1902.[1] (See References, p. 373.)

SELECTION.

The chief variations to be looked for amongst existing races of cane may conveniently be classed under three heads: (a) Variations in habit and vigor of growth; (b) Bud variations; (c) Variations in sugar contents of individual canes.

(a) Variations in habit and vigor of growth.—Amongst a large area of canes of any single variety, there were always to be seen some canes distinguishable by greater size and vigor. Planters were advised to select and cultivate such canes, as their great vigor seemed to indicate a greater power of resisting attacks of disease. This method has been tested practically under scientific supervision in the West Indies, and it has been found that many of the canes thus selected were capable of producing larger yields of sugar. Investigation of the more vigorous canes showed that they frequently varied to a considerable extent from the main crop, and therefore it is quite probable that many of them, instead of being variations of the mother type, were really seedlings which had come up in the fields, and had become cultivated in the next crop. Some of these variations could not be accounted for in any other way, and it was this peculiar appearance of new varieties of canes that subsequently led to the discovery of canes growing from seed.

(b) Bud Variations.—But varieties or *sports* are not uncommon in the sugar-cane. In fact, in 1886, a communication was addressed from the Royal Gardens, Kew, to all the sugar-producing colonies to stimulate inquiry into the advisability of searching for and cultivating sports on a large scale, as it was probable that some of these varieties would prove hardier and give a greater amount of sugar than the original stock.

In the summary of the observations on bud varieties of the sugar-cane up to 1901, given in the West Indian Bulletin, Vol. II., pp. 216-23, instances of such variations were recorded from widely separated countries, viz., Mauritius, Louisiana, West Indies and Queensland.

Since then, other bud varieties have been noticed in the West Indies, and quite recently, two interesting accounts of sports have come to hand from Madras and Queensland.

In Queensland, one of the seedling canes has produced a sport which gave an analysis of 19.72 per cent. saccharose, as against 19.03 per cent. saccharose of the parent cane, and 18.97 per cent. of the next best seedling. It would appear that sports generally arise from striped or ribbon canes, and usually keep true to a whole color; but instances have recently occurred in Barbados in which a green cane has given rise to a green and white striped sport. Clark, Queensland, holds that "yellow sports have a tendency to grow sweeter than the colored canes of the kindred variety." This is not borne out by the instance lately recorded from Madras, for a striped cane has been found to sport into red and white canes, and "whereas the white cane gave on analysis very similar results to the parent cane, the red sports excelled all other canes in the station in purity of juice."

In order to put the relative merits of the sport canes and the original stock to a strictly comparative test, they were planted at the Experiment Station, Dodds, Barbados, side by side, in the same field, with other experiment canes.

The following figures taken from the report of Messrs. d'Albuquerque and Bovell on the agricultural work carried on at Barbados, 1900-2, under the direction of the Imperial Department of Agriculture for the West Indies, show the results obtained. For comparison, the return of White Transparent grown in the same field is also given:

TABLE I.

CANE.	Canes—Tons per acre.	Juice per acre in Imperial gallons.	Pounds of saccharose per gallon.	Quotient of purity.	Pounds of saccharose per acre.
Original Stock (ribbon) ..	21.80	2,696	2.310	93.03	6,228
Sport Cane (white)	27.27	3,555	2.270	91.64	8,070
White Transparent	23.93	3,063	2.001	86.59	6,129

The yield from the sport cane in the experiments exceeds the yield from the original stock cane by nearly 2,000 pounds of saccharose per acre. This superiority was due to the higher tonnage of the white canes, their juice being slightly less rich in saccharose, and slightly less pure than the ribbon stock. The juice of both original stock and sport was rich in saccharose, and the results, so far, warrant their continued experimental cultivation.[2]

During the season 1903-5, this sport maintained its superiority over White Transparent, as may be seen from the following table, which gives the mean results for these two varieties obtained from experimental plots on black-soil estates, together with the results of a Ribbon Cane, and of a Red Sport cane. This latter, as can be seen from the table, has not proved satisfactory, but during the last growing season has been very vigorous and should give much better results:

TABLE II.

CANE.	Canes—Tons per acre.	Juice per acre in Imperial gallons.	Pounds of saccharose per gallon.	Quotient of purity.	Pounds of saccharose per acre.	Per cent. by No. of rotten canes.
White Sport*	26.06	3,407	1.954	84.45	6,645	1.55
White Transparent*.	22.83	2,760	2.123	90.45	5,864	2.35
Ribbon Cane†	21.78	....	2.070	....	5,735	...
Red Sport†	19.23	....	2.051	....	5,131	...

Without doubt, these bud varieties deserve much more attention than is given to them, both on account of their economic importance, and also because the study of their variations may yield results of scientific and, probably, practical value. As to the cause of the real nature of these bud varieties very little is known at present. It has been suggested that these striped or ribbon canes are the results of cross-fertilization and that, therefore, the sports are to be considered as cases of dissociation and then segregation of hybrid characters, or of *atavism*.

It is supposed that unfavorable influences, either external or internal, temporarily encumber the growth of the young buds and predispose them to reversions. But, if sports are of an atavistic nature and are favored by influences that impede normal growth, how is it that they, almost without exception, give such excellent results when cultivated, being hardier and richer than the original stock from which they arose?

(c) Variations in sugar contents of individual canes.—Bearing

*These results have been taken from Pamphlet No. 40 of the Imperial Department of Agriculture for the West Indies.

†These results have been obtained through the courtesy of Mr. J. R. Bovell, Agricultural Superintendent, Barbados.

in mind the classical experimental work, with which the name of de Vilmorin is associated, in selection of the sugar beet, by which, through the aid of science, the sugar content has been raised from 10 to 18 per cent., workers with sugar-cane were led to commence investigations with regard to the chances of obtaining canes of higher saccharine content. The occurrence of a wide range of variation in the percentage of saccharose in the juice of canes of the same age and variety was soon noticed, and the fact that the sugar-cane was propagated by cuttings naturally suggested that any improvement inherent in the plant could be developed more rapidly than if it had to be grown from seeds. Investigations in chemical selection have been carried out in the West Indies, but the results, so far obtained, are not at all conclusive.

D'Albuquerque, Barbados, at the last West Indian Agricultural Conference, 1905, stated that it would appear "that, with a given variety, the richness or poorness of the seed-cane (i. e., cane used for planting) does not affect the quality of the juice of the resulting crop." Harrison, British Guiana, concludes that the "relative richness of seedlings is qualitatively, if not quantitatively, constant." Watts, Antigua, however, states that "some difference is induced by the process of selection, and, while this method of work is not likely to be followed by practical planters as a means of improving their canes, yet the fact is interesting from its scientific aspect as indicating that plants propagated by cuttings are subject to slight alterations.[3]

In Queensland it has been stated that improvement from single-stalk selection is not as great as would be expected, while in Java the evidence seems to point to the fact that selection amongst "cane-clumps" is likely to give better results than selection among individual canes.

The following is the summary of the results of chemical selection investigations by Kobus in Java up to 1902, and has been abstracted from the Journal of the Royal Horticultural Society, 1903 (Vol. XXVIII, p. 298) :—

"1. The amount of sugar in the individual haulms of one sugar plant was apt to vary greatly.

"2. The variability of the amount of sugar in the different varieties was greatest in thick-stemmed varieties that had long been in cultivation, and least in young ones more recently selected from seed.

"3. The amount of sugar in the cane varied directly with the weight of the same.

"4. Heavy plants gave rise to heavy offspring.

"5. The descendants of plants rich in sugar were richer in sugar and heavier than unselected plants.

"6. Simple selection of cuttings of heavy plants did not lead to the production of forms markedly rich in sugar, though the resulting plants were in general richer in sugar. Indeed, heavy plants poor in sugar seemed to have a worse effect on the amount of sugar in the progeny than did light plants poor in sugar.

"7. Extreme care had to be exercised in the selection of the ground on which the experiments were made; for, even in apparently uniform soil, great differences were apt to appear in the individual plants merely in consequence of local variations in the soil.

"8. Increased vigor as reflected in larger yield of sugar was accompanied by greater immunity from 'sereh' disease."

This report is valuable as it confirms some results obtained elsewhere and at the same time presents many facts of great importance to those interested in raising seedling canes.

INTRODUCTION OF FOREIGN VARIETIES FOR FIELD CROPS.

The introduction and trial of standard varieties of sugar-cane from other countries is of considerable interest to planters, as probably this was the principal means by which the sugar-cane was distributed throughout the tropics.

Evidence, on the whole, seems to point to India and Polynesia as the original home of the sugar-cane, but it is now cultivated in various localities on both sides of the Equator ranging from the south of Spain, 37° north, to New Zealand, 37° south.

Of the older varieties of cane there appear to have been three or four which were extensively cultivated. In those countries where these are still free from disease, very few others have, as yet, taken their place; but where their cultivation has become impossible on account of the ravages of disease, others have been introduced to take their place.

In the West Indies, the Bourbon and Otaheite canes have almost entirely been replaced by other improved and hardier varieties. In Java, the introduction of the East Indian cane Chunnee was rendered necessary owing to the home cane being very liable to the "sereh" disease.

Within the range of cultivation of the sugar-cane there are yet many countries where it might be largely grown if only the prevailing low prices should improve.

With the introduction of imported varieties it should be realized that there is always a danger of introducing new diseases and pests. It is important, therefore, that all imported plants be carefully fumigated and disinfected before being allowed to enter any country. Throughout the West Indies, laws of fumigation and disinfection of all imported cane cuttings are generally enforced, and, now that seedling canes are beginning to play such an important part in the improvement of the sugar-cane, and their introduction into new lands is becoming universal, it cannot be too strongly urged that all cane-growing countries should adopt means to prevent the introduction of new pests and diseases.

HYBRIDIZATION.

Having briefly reviewed the methods of selection, and the introduction of foreign varieties, it is now proposed to deal with the question of the improvement of the sugar-cane by hybridization. Although, perhaps, the contents of this paper may not appear to be in line with other papers read at this Conference, yet they may prove of value to our tropical possessions in showing what efforts are being made by cane growers in the colonies and elsewhere, to compete with the beet sugar production of European countries.

In Europe and America, much of the progress of agriculture during the last fifty years has been due to the continual improvement of the cultivated varieties of plants and to the production of new varieties.

In the tropics, such work, until lately, has been almost entirely neglected, and therefore a record of practically the first work in this direction should be interesting. Although such work has been possible for eighteen years, it is only within the last decade that systematic attempts have been made to raise seedling sugar-canes on a large scale. The remainder of this paper can therefore be divided into two parts, the first dealing with the different methods of producing hybrid canes that have been adopted by those working for this improvement, together with some of the results obtained, and the second part treating with the individual advances made by some of the more important cane-growing countries.

HISTORICAL.

The sugar-cane belongs to the *Andropogoneae*, a family of the true grasses *(Gramineae)*. It has a solid stem, which often attains a height of nearly 20 feet, and contains the sweet juice from which the sugar is extracted. It is now generally conceded that all cultivated varieties of canes belong to one species, *Saccharum officinarum*, L., but there are reasons for believing in the existence of at least three other species. None of these, however, are regarded as of economic importance.

It would appear that sugar-canes, probably produced from seed, were observed at Barbados in 1848 and 1850, and the question respecting the possibility of growing seedling canes in the West Indies was raised at various times between 1859 and 1888. In the latter year, Harrison and Bovell from Barbados communicated to Kew that they had sixty cane plants under cultivation and that they were almost satisfied that they were seedlings.[4] This eventually proved to be so, and from that time systematic attempts to raise new varieties of seedling canes in Barbados, British Guiana, and elsewhere in the West Indies have been undertaken with highly satisfactory results.

A similar announcement as to the possibility of raising seedling sugar-canes was made by Soltwedel in Java in 1887.

Previous to 1887 or 1888 it was generally believed that the sugar-cane, in common with the banana and other tropical plants, had lost its power of producing fertile seed, and that all recorded observations of new canes up to this time were bud varieties or sports. However, since the establishment of the fact that the cane does produce fertile seed, the improvement of the sugar-cane by hybridization has made wonderful strides, and now experiments, conducted on scientific lines, are being carried out in Java, India, Hawaii, Queensland, Cuba, British West Indies, and British Guiana, etc., with the hope of raising canes less susceptible to disease and yielding a larger amount of sugar per acre.

DESCRIPTION OF FLOWER.

Before dealing with the different methods of obtaining hybrids, it may be advisable to give a description of the flower of the sugar-cane. The flower has often been described and figured, while good descriptions of the seed and its germination were given by Benecke in the Bulletin of the Middle Java Experiment Station, 1889, and also by Morris in the Journal of the Linnean Society, 1890.

The following description has been taken from notes made from the examination of many hundred flowers of different varieties during hybridization experiments this last year at Barbados, in 1905-6:

The inflorescence or *arrow* varies from 2 feet to 3 feet in length. It is repeatedly branched, each branch bearing laterally a number of spikelets. The numerous spikelets are one-flowered and hermaphrodite, and are generally arranged in pairs, one being sessile and the other stalked, at distances of a little more than ⅛ inch on alternate sides of the slender, long branches. From the base of each spikelet, attached to the rachis, spring a large number of stiff, long, silky hairs, which give the inflorescence a glistening silky appearance in the sun.

The flower has the following formula:

Glumes, 2; *Palea*, 1; *Lodicules*, 2; *Stamens*, 3; *Ovary*, single; *Style*, 1 (bifid).

The two glumes are nearly equal; oblong-lanceolate, acute; unawned; stiff; at first green, then purplish, the intensity of which varies in different varieties. The lower is two-nerved and measures 2.5 to 3.6 mm. long, by 0.7 to 0.9 mm. wide. The upper is distinctly one-ribbed, slightly keeled, and measures 2.8 to 3.8 mm. long, by 0.8 to 1.3 mm. wide. These measurements are the average of many investigations on different varieties, for, whereas the size of the glumes is generally constant in any given variety, between different varieties considerable variations have been observed.

The palea is solitary, thin, white, membranous, and is enclosed in the upper glume, than which it is slightly shorter. It is ovate-lanceolate, slightly obtuse, generally smooth, and apparently unveined.

The two lodicules are free, minute, truncate or 2-3 lobed, and vary in color from white to yellowish green.

The stamens are three in number (during hybridization experiments at Barbados in 1905-6 three instances of four were found and noted), the anthers are linear-oblong, versatile, and vary in color from yellow when young to a deep yellowish-red when mature.

Ovary smooth, unicarpellary, style one, bifid. The styles vary considerably even in the same variety, for in some instances a single style springs from the top of the ovary and soon becomes bifid; while, in others, there are two styles distinct throughout. The stigmatic plumes are always two in number and are large, densely plumose, and dark reddish purple.

The fact that the anthers are versatile and the stigmatic plumes feathery would lead to the conclusion that the sugar-cane, like the majority of the grasses, is naturally wind pollinated; for when the versatile anthers burst, the pollen is much more easily scattered by the wind than would be the case if they were firmly fixed; it is also the more easily caught by the feathery stigmata. This is a point that is still under investigation and is one of considerable importance in the work of hybridization.

METHODS OF OBTAINING SEEDLINGS.

In some countries the earliest method adopted for obtaining seedling canes was by a collection of fertile seeds or casually produced seedlings from the fields.

A later step was the identity of the seedlings from the seed-bearing parent. This method was the one early adopted by Harrison and Jenman in British Guiana. The cane from which the arrow was taken was carefully recorded, and thence commenced a stock of new varieties of canes with the parentage known on one side only.

A further stage was the raising of seedlings from two varieties of canes by planting in adjoining rows varieties known to arrow at the same time. By this means there was a possibility that the pollen-bearing parent might be identified as well as the seed-bearing parent.

Thousands of seedlings have been raised by these methods, but, although the seed-bearing parent was known and registered, the pollen-bearing parent was still uncertain. In consequence, a large majority of the seedlings were found to be less valuable than the seed-bearing parent originally selected. In many cases, however, it was evident that the resulting seedling canes were true hybrids. These hybrids, when they possessed a vigorous habit and a high saccharine content, were carefully propagated and subjected to a rigorous system of selection.

The fixing of good varieties was rendered more easy, as plants raised from cuttings come true to the parent forms, and do not necessitate additional selection year after year. After these seedlings had been sufficiently investigated to warrant recommendation to the planters, they were gradually introduced into general cultivation, and have proved the means of overcoming to a considerable extent the ravages of disease, as many were hardier than their parent forms.

Through the uncertainty of the results of the above-mentioned methods of what may be called natural or chance hybridization, it was considered advisable to conduct hybridization under control, and by this means it was hoped to combine some of the desirable characters of both parents, and therefore produce pedigree canes, which could be recommended for general cultivation.

At the second West Indian Agricultural Conference of Barbados in 1900, d'Albuquerque, after discussing methods in securing natural hybrids which, hwever, did not ensure against the risk of pollen from an unknown source, recommended an artificial method of securing cross-pollination, e. g., "to bag each arrow under experiment some time before it is ripe, and when the arrows in the bags are ripe, to shake the contents of the bags of one variety into the bags covering the arrows of another, the latter bags being temporarily opened at the top to receive the pollen, and then closed up; every possible precaution being taken to prevent, during the transference, the access of pollen from any other source."[5]

It was, however, pointed out that such a method did not entirely prevent self-pollination, and therefore it has been replaced by others in which the risk is not so great.

In 1894, it was found by Wakker in Java that the Cheribon cane did not bear fertile pollen while the pistil was normal, and therefore any seedlings raised from this cane would be the result of cross-fertilization. This was a great advance in the hybridization problem of the sugar-cane. Kobus, by planting other good varieties known to possess fertile pollen by the side of this Cheribon cane, obtained thousands of seedlings as the result of inter-crossing. Investigations in Java upon the raising of sugar-cane seedlings centered around this discovery, and, therefore, in 1902 a large number of the best seedlings canes at Barbados were examined by Lewton-Brain[6] in the laboratory of the Imperial Department of Agriculture for the West Indies to inquire into the proportions of fertile to infertile pollen in the anthers of different varieties. By this means it was possible to divide the West Indian varieties of canes into three classes: (1) in which the anthers show a large proportion of normal pollen; (2) in which the anthers show a very small proportion of normal pollen; (3) in which the anthers show a moderate proportion of normal pollen. If, therefore, an arrow of a cane producing much normal pollen is bagged with an arrow of a cane producing little fertile pollen, the risk of self-fertilization is reduced to a minimum, and if fertile seeds are produced by these canes, they will almost certainly be the result of hybridization.

The possibilities of the hybridization of the sugar cane under control, by removing the stamens of one flower and the transference of pollen from another, were discussed by Boname, Mauritius, in 1899. It was thought, however, that this was almost impracticable on account of the large number of flowers on each panicle, and also their microscopic size. It was also pointed out that it was not known, with certainty, whether the flowers of the sugar cane were autogamous or not, and, therefore, emasculation would have to take place while the flowers were very young. The emasculation of immature spikelets of the sugar cane without injuring the very delicate ovary and stigmatic plumes was thought to be an operation of considerable difficulty, and, therefore, the raising of seedlings by hybridization under control was dismissed as being impossible. In 1900, d'Albuquerque stated that, to ensure that the seedling canes produced are the result of cross-fertilization between the parent selected "would need the elimination of the anthers before they were mature—a very difficult task in a plant, the parts of whose flowers are so small as in the sugar cane;" but in 1904, Lewton-Brain, after consultation with d'Albuquerque and Bovell, performed experiments in artificial cross-pollination, in which the flowers of one variety were emasculated while still young, covered in a muslin bag, and then pollen from another variety was transferred to them by hand. This method of raising hybrids by artificial cross-pollination proved successful. Five stools of hybrid canes were raised in Barbados as the result of this work. It is reported that four pedigree hybrids have been raised in Queensland, and in Cuba about 600 are said to be now under investigation.

The operation of emasculating the flowers has to be performed under a dissecting miscroscope upon a platform 8 or 9 feet above the ground. Such an operation under field conditions with a strong wind blowing is attended with considerable difficulty. Even when accomplished, an unfavorable season with very hot dry winds or heavy rains is likely to destroy the chance of good results. That so much depends upon the season may be seen by the results from Cuba. Four years' work yielded but two hybrid seedlings, while the work of a single favorable season produced 600.

Having established the fact that hybrids of sugar cane can be obtained by cross-pollination under control, it remains to discuss briefly the best methods of attacking the problem of raising disease-resistant varieties with a large sugar content.

(To be Continued.)

Sugar Plantations, Cane Growers and Sugar Mills.

ISLAND AND NAME.		MANAGER.	POST OFFICE.
OAHU.			
Apokaa Sugar Co.	*	G. F. Renton	Ewa
Ewa Plantation Co.	*	G. F. Renton	Ewa
Waianae Co.	***	Fred Meyer	Waianae
Waialua Agricultural Co.	*	W. W. Goodale	Waialua
Kahuku Plantation Co.	x*	Andrew Adams	Kahuku
Waimanalo Sugar Co.	**	G. Chalmers.	Waimanalo
Oahu Sugar Co.	x	E. K. Bull	Waipahu
Honolulu Plantation Co.	**	J. A. Low	Aiea
Laie Plantation	x*	S. E. Wooley	Laie
MAUI.			
Olowalu Co.	**	Geo. Gibb	Lahaina
Pioneer Mill Co.	x	L. Barkhausen	Lahaina
Wailuku Sugar Co.	**x	C. B. Wells	Wailuku
Hawaiian Commercial & Sug. Co.	x*	H. P. Baldwin	Puunene
Maui Agricultural Co		H. A. Baldwin	Paia
Kipahulu Sugar Co.	x	A. Gross	Kipahulu
Kihei Plantation Co.	x*	James Scott	Kihei
HAWAII.			
Paauhau Sugar Plantation Co.	**	Jas. Gibb	Hamakua
Hamakua Mill Co.	*x	A. Lidgate	Paauilo
Kukaiau Plantation	x	J. M. Horner	Kukaiau
Kukaiau Mill Co.	*x	E. Madden	Paauilo
Ookala Sugar Co.	**x	W. G. Walker	Ookala
Laupahoehoe Sugar Co.	*x	C. McLennan	Papaaloa
Hakalau Plantation	**	J. M Ross	Hakalau
Honomu Sugar Co.	**x	Wm. Pullar	Honomu
Pepeekeo Sugar Co.	**x	Jas Webster	Pepeekeo
Onomea Sugar Co.	**x	J. T. Moir	Hilo
Hilo Sugar Co.	**	J. A. Scott	Hilo
Hawaii Mill Co.	x	W. H. Campbell	Hilo
Waiakea Mill Co.	*x	C. C. Kennedy	Hilo
Hawaiian Agricultural Co.	**x	Wm. G. Ogg	Pahala
Hutchinson Sugar Plantation Co.	**	Carl Wolters	Naalehu
Union Mill Co.	*x	H. H. Renton	Kohala
Kohala Sugar Co.	*	E. E. Olding	Kohala
Pacific Sugar Mill	x**	D. Forbes	Kukuihaele
Honokaa Sugar Co.	x**	K. S. Gjerdrum	Honokaa
Olaa Sugar Co.	xx	J. Watt	Olaa
Puna Sugar Co.			Kapoho
Halawa Plantation	x*x	T. S. Kay	Kohala
Hawi Mill & Plantation	‡‡	John Hind	Kohala
Puako Plantation	‡‡	Jno. C. Searle	S. Kohala
Niulii Sugar Mill and Plantation	*x	Robt Hall,	Kohala
Puakea Plantation	*x	H. R. Bryant	Kohala
KAUAI.			
Kilauea Sugar Plantation Co.	**	Frank Scott	Kilauea
Gay & Robinson	x*x	Gay & Robinson	Makaweli
Makee Sugar Co.		G. H. Fairchild	Kealia
Grove Farm Plantation	x	Ed. Broadbent	Lihue
Lihue Plantation Co.	x	F. Weber	Lihue
Koloa Sugar Co.	x	P. McLane	Koloa
McBryde Sugar Co.	*x	W. Stodart	Eleele
Hawaiian Sugar Co.	x*	B. D. Baldwin	Makaweli
Waimea Sugar Mill Co.	*	J. Fassoth	Waimea
Kekaha Sugar Co.	x	H. P. Faye	Kekaha

KEY.	HONOLULU AGENTS.	
.	Castle & Cooke	( )
**	W. G. Irwin & Co.	(8)
***	J. M. Dowsett	(1)
x	H. Hackfeld & Co.	(9)
*x	T. H. Davies & Co.	(8)
**x	C. Brewer & Co.	(6)
x*	Alexander & Baldwin	(6)
x**	F. A. Schaefer & Co.	(2)
x*x	H. Waterhouse Trust Co.	(2)
‡‡	Hind, Rolph & Co.	(2)
xx	Bishop & Co.	(1)