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MACHINES FOR THE TREATMENT OF COTTON SEED AGAINST PINK BOLL WORM

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MINISTRY OF AGRICULTURE, EGYPT.

TECHNICAL AND SCIENTIFIC SERVICE.

Bulletin No. 14.

(ENTOMOLOGICAL SECTION.)

MACHINES FOR THE TREATMENT OF COTTON SEED AGAINST PINK BOLL WORM

(*Gelechia gossypiella* Saund.),

BY

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ENTOMOLOGIST TO THE MINISTRY OF AGRICULTURE.

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(ENTOMOLOGICAL SECTION).

MACHINES FOR THE TREATMENT OF COTTON SEED AGAINST PINK BOLL WORM

(*Gelechia gossypiella* SAUND.).

It is now a matter of general knowledge that the pink boll worm passes through the winter in a resting condition, either in the dead bolls left on the cotton sticks and the ground after the previous year's harvest, or in the cotton seed. As regards the former, for the last three years the Ministry of Agriculture has endeavoured by its boll worm campaign to induce cultivators to collect and burn the dead bolls in order to reduce the menace to the next year's crop. The present paper deals only with the question of the cotton seed which has occupied the attention of the Entomological Section since 1912. Since the completion of the laboratory stage of the experiments progress has been slow, partly owing to the general attitude of apathy and, in some cases, even of opposition on the part of ginners and others concerned, and partly owing to the difficulties of various kinds occasioned by the war. However, a law has now been passed making the treatment of cotton seed against pink boll worm compulsory, and it has therefore been thought advisable to publish a brief *résumé* of what has been done, giving short accounts of the various types of machines that have been proposed.

In December 1913, when the pink boll worm was just beginning to be regarded as a major pest, a fairly exhaustive series of laboratory experiments was carried out to test the various methods of killing the worms without damaging the seed. The results of these experiments were published in the "Agricultural Journal of Egypt," 1913, Volume III, Part II (Gough and Storey, "Methods for the Destruction of the Pink Boll Worm in Cotton Seed"), the conclusions arrived at being :—

"Three different methods of destroying *Gelechia* larvæ have been found effective and commercially applicable, namely :—

"(1) Hot-air treatment.

"(2) Treatment by poisonous gases.

"(3) Treatment by soaking in cyllin solution 1 : 1,000.

"The methods indicated under (1) and (2) are applicable on a large scale at the time of ginning and (3) only immediately before sowing. No treatment is possible when the seed is in the sacks."

As soon as these conclusions had been reached, an experimental hot-air machine was erected by M. Crovisier of the State Domains Administration, and a carbon bisulphide fumigation machine was constructed by Messrs. Thos. Cook & Son to a design of the Entomological Section. Both these machines were exhibited at Sakha in June 1914 to a meeting of ginners and others interested, and reports on them were published in the "Agricultural Journal of Egypt," 1914, Volume IV, Part II (Storey, "Notes on Large Scale Experiments against the Pink Boll Worm in Cotton Seed"), together with a note on a mechanical cleaner devised and built by Messrs. W. R. Dell & Son, of London. In spite of the fact that the two former machines were successful in doing what was asked of them, neither of them found favour with the ginners, the hot-air machine on account of its clumsiness and immense size compared with its output together with the danger of damaging the seed by overheating, and the fumigation machine on account of the poisonous and inflammable qualities of carbon bisulphide. The objections to the latter were apparently more serious than to the former. The Entomological Section therefore turned its attention to the hot-air treatment and designed an experimental machine, on much the same principle as some of the tea-drying machinery made by Messrs. Marshall & Sons. Though still very cumbersome, this was much less so than the Domains machine, and having a larger output gave one a better idea of the commercial possibilities of the process. This machine was to have been completed by February 1915. Owing to difficulties caused by the war, however, it was not actually delivered till November of that year.

In the meantime a proposal was made by Mr. Victor Mosseri to fumigate the seed with hydrocyanic acid gas *in vacuo.* He also elaborated an apparatus for recovering the gas after treatment, thus reducing the danger of poisoning to a minimum. Laboratory experiments to test the method had proved successful, and as a very similar method is used in America for fumigating steam-pressed cotton bales, apparently with complete success, it was taken for granted that the process would prove equally successful in treating cotton seed on the large scale. A full-sized apparatus was therefore ordered from Messrs. Sulzer Frères of Winterthur, Switzerland, to Mr. Mosseri's design. Demonstrations of the process with an experimental apparatus were made in May 1915 before H.H. the Sultan, and in June before delegates from the Ministry of Agriculture. The full-sized machine was definitely ordered in September and was to have been ready for use during December. However, owing to various delays it was not ready for trial till August 1916. By that time practically all the pink boll worms had left the previous season's seed and tests could not be made until the new season's seed was available.

During this delay, however, a big advance had been made by the erection of a new type of hot-air machine as a commercial enterprise. Hitherto all experimental machines had been erected at Government cost and the Government had borne all other expenses connected with the experiments. In the latter half of 1915, however, Messrs. Mosseri, Curiel & Co., of Cairo, brought from England a malt-drying machine of the type made by Messrs. Richard Simon & Sons, of Nottingham, and asked the Ministry of Agriculture to test it with a view to finding whether it could be utilized for treating cotton seed. A preliminary trial was carried out during February 1916. This was, however, of little use owing to the absence of certain accessories. Further trials were carried out in April after the more important defects had been remedied, the results being published in the Ministry of Agriculture's Bulletin No. 11 (Storey, "Simon's Hot-air Machine for the Treatment of Cotton Seed against Pink Boll Worm").

This machine differed in principle from the previous hot-air machines that had been proposed, the seed being heated, not by hot air, but by direct contact with steam-tubes. In fact the machine is not really a "hot-air" machine at all. The name has, however, come to be adopted for want of a better, so it is idle to try to change it now.

This change in principle immediately overcame the great objection to the true hot-air machines, namely, their immense size compared with their output. The results of the experiments proved quite satisfactory, particularly so considering that the machine in question was only erected as an experimental model and was not fitted either with a satisfactory feed or with adequate means for regulating the steam pressure.

In spite of demonstrations, however, it became increasingly obvious that nothing would be done by the ginners until it was made compulsory by law to treat all the seed in the country against pink boll worm. There were many difficulties in the way of such a law, particularly during war time, and inquiries connected with them occupied a considerable amount of time. However, the law (No. 29 of 1916) was eventually promulgated on December 15, 1916, to the effect that during the coming ginning season, *i.e.* 1917 to 1918, all cotton seed must be treated against pink boll worm with a machine approved by the Ministry of Agriculture. At the same time an effort was made to reduce the danger from worms in the seed to a minimum during the current season by prohibiting the storage of cotton seed and unginned cotton in the country after May 1, except in licensed moth-proof stores. Later it was found to be impossible to obtain a sufficient number of machines for the whole of Egypt for the 1917–1918 ginning season. Consequently it has been decided not to enforce the law during the coming year.

The promulgation of the law, however, had an immediate effect on the activities of the ginners and local manufacturers such as all the previous demonstrations and recommendations had failed to produce, and during the four months following its publication the Ministry of Agriculture received more than twice as many suggestions for machines for treating cotton seed as had been received in the previous four years. Some of these were merely adaptations of others, some have not proved successful, and others have not yet been tested. All, however, are briefly described below, in the hope that the descriptions will prove of interest and value to any one contemplating the erection of machinery for the treatment of cotton seed.

Fumigation Machines.

Five more or less different machines have so far been proposed involving the use of poisonous gases : the Ministry's original machine and one proposed by M. Gayet, involving the use of carbon bisulphide ; Mr. Mosseri's and an adaptation of the American baled cotton fumigator, employing prussic acid gas ; and, finally, a machine proposed by Messrs. Wells and Hayman, in which the fumes from the distillation of cotton sticks are used as the killing agent.

(1) *The Ministry of Agriculture's Carbon Bisulphide Fumigator.*— A full description of this machine was given in the "Agricultural Journal of Egypt," 1914, Volume IV, Part II, page 119. It is therefore of little use repeating it here. Suffice it to say that, so far as the treatment itself is concerned, this machine is the most successful of any yet erected, giving a regularly complete mortality of the worms with no possibility of damaging the seed in any circumstances whatever. The machine was very cheaply erected, had a capacity of twenty ardebs per hour, and was economical in running, the only expenses being chemicals at less than P.T. 1 per ardeb, and a small amount of power and labour. The objections raised to the use of carbon bisulphide on account of its poisonous and inflammable qualities were, however, so strong that the machine was abandoned.

For further particulars, see the report referred to above or apply to the Ministry of Agriculture.

(2) *Mosseri's Cyanide Fumigator.*—This machine has already been referred to at some length above. The installation at Kafr el Zayât consists of eight cylinders, each with a capacity of about ten ardebs, a powerful air pump worked by an oil engine for exhausting the cylinders and the necessary apparatus for producing, drying, and distributing the hydrocyanic acid gas. At first an apparatus was also attached for recovering the gas after use by means of caustic soda, but owing to the difficulties and dangers of handling this without employing a trained chemist it was decided to burn the gas after use by passing it through a small furnace.

In practice a cylinder is filled with seed and closed down. The air is then exhausted as far as possible. The gas, mixed with a certain amount of air, is admitted and left for half an hour to take effect.

At the end of this time the gas is drawn out again, and then a current of air is circulated to remove the last traces of the gas as far as possible before the seed is taken out and sacked.

The machine has been tested by Mr. Aladjem, the Ministry's Assistant Chemist. He states that in the first trials carried out during August, when the temperature was high, the results were entirely satisfactory, but that when the weather became cooler it was found to be necessary, as was anticipated by Mr. Mosseri, (1) to dry the gas, and (2) to keep the temperature of the seed and apparatus above 27° in order to prevent the condensation of the gas. For the latter purpose, owing to the lack of facilities for having an elaborate piece of apparatus made, the seed was either spread out in the sun or heated by means of a somewhat primitive hot-air machine improvised from the materials available. In this way it was found that when the temperature of the seed was about 30° C. the mortality of the worms was generally about 93 per cent.

It appears from this that the question of condensation makes it essential that machines of this type should be provided with some apparatus for keeping the temperature of the whole plant at least as high as 27° C.

Fumigation with hydrocyanic acid gas has no effect on the germination of the seed.

The machine has been approved by the Ministry of Agriculture, subject to certain conditions imposed by the Department of Public Health.

For further particulars apply to Mr. Victor Mosseri, Ingénieur Agronome, Cairo, or to the Ministry of Agriculture.

(3) *American Cyanide Fumigator.*—During 1914 a proposal was made by Mr. Dudgeon, Consulting Agriculturist to the Ministry of Agriculture, to employ a machine of the type used by the American Government for fumigating imported bales of cotton. In principle the machine is exactly the same as the last, but the seed, instead of being fed into cylinders in bulk and sacked after treatment, is first sacked and then run on trucks into a horizontal cylinder. A machine of this type was actually ordered, but, owing to the difficulty of getting the work executed during the war, the order afterwards had to be cancelled. The machine has apparently proved quite successful in fumigating steam-pressed bales of cotton, but whether it would

meet with the same difficulty as Mosseri's machine, owing to the absorption of the gas by the seed, it has been impossible to test. Possibly the air spaces between the sacks would enable the gas to penetrate more thoroughly.

For further particulars apply to the Ministry of Agriculture.

(4) *Gayet's Carbon Bisulphide Machine.*—A method proposed by M. Gayet, engineer to Mr. J. G. Joannides' ginnery at Tanta, consisted of a combination of the principles involved in all the three foregoing machines. The inventor proposed to have a fumigation chamber similar to the American one, and after it had been charged with seed and the air exhausted from it, it was to be connected with an iron retort containing charcoal, on to which sulphur could be dropped through a broad-gauge valve, the retort being kept red-hot in a furnace. The evolved carbon bisulphide would then flow into the fumigation chamber and, owing to the vacuum that had been produced, would penetrate everywhere.

M. Gayet fitted up a small experimental apparatus taking about one ardeb of seed and got perfectly satisfactory results with it. It is possible that on the large scale condensation effects such as were obtained with Mosseri's machine might interfere with the results, but carbon bisulphide does not seem to be absorbed by cotton seed in the same way as hydrocyanic acid gas, and the fact that there was no difficulty in getting a free circulation of the vapour in the Ministry's machine, would indicate that the probabilities of difficulty from this source are not great. However, the objections to the machine are the same as the objections to the Ministry's machine, namely, the poisonous and inflammable qualities of carbon bisulphide. The separate production of each dose on the spot reduces these objections to a minimum by avoiding the necessity of keeping any stock of carbon bisulphide, and as arrangements could be made for washing the carbon bisulphide out of the seed with a current of air before opening the fumigation chamber, the danger, either of poisoning or of explosions, should be very small indeed. However, before erecting a machine on these lines it would certainly be wise to ascertain the opinion of the insurance societies and of the Department of Public Health.

For further particulars apply to M. A. Gayet, c/o Mr. J. G. Joannides, Tanta.

(5) *Wells and Hayman's Cotton Seed and Cotton Stick Fumigator.* — Mr. John Wells, Consulting Engineer to the Egyptian Government, has recently submitted the plans for a machine designed by himself in conjunction with Mr. Hayman, for killing pink boll worms in the bolls left on cotton sticks after the last picking by fumigating them with the fumes given off by distilled cotton sticks. He remarks that this method could also be used for treating cotton seed. The apparatus figured consists of a vat which will hold forty tons of cotton sticks after they have been chopped up into pieces not more than two inches long, this chopping causing a reduction in volume to about one-sixth of the volume of the unchopped sticks. Into the top of this vat is led a tube from a retort in which the cotton sticks are distilled, the air forced out during the process being allowed to escape from the bottom of the vat. Presumably, if this machine were to be used for cotton seed, considerable modifications would be made in order to adapt it to the requirements of the ginnery.

So far, however, not even a small-scale machine has been built on these lines, so that it is impossible to say whether the fumes would penetrate the seed sufficiently to kill the worms, or whether the tarry products in the distilled gases would have a deleterious effect on the germination of the seed.

For further particulars apply to Mr. John Wells, Consulting Engineer, Sharia Sheikh Abu el Sebaa, Cairo.

Hot-air Machines.

Before proceeding to deal with individual hot-air machines in detail it will perhaps be well to discuss a few general problems in connection with hot-air treatment.

The first question which is always asked is " What temperature kills the worm and what length of time is necessary ? " There seems to be, however, a very general misapprehension as to what is meant by a reply to this question. For instance, if one says that five minutes at a temperature of 55° C. will kill all the worms, this does not mean that if seed containing worms is placed in a hot-air chamber, the air in which is at a temperature of 55° C., and left there for five minutes, all the worms will be found dead at the end of that time. They probably would not be. What it does mean is that if the worms themselves are heated up to 55° C. and maintained at that temperature for five minutes they will all be killed. The difficulty is that it is impossible to determine the temperature of an individual worm at any given time. and still more out of the question to follow the variations in temperature through which it passes during its transit through a hot-air machine. It has been found in practice that the most comparable results are obtained by registering the temperature of the seed immediately after leaving the machine. In the majority of machines —two exceptions to this are discussed below the seed is then at its maximum temperature and the worms may be regarded as being at as nearly as possible the same temperature. The time during which the worms remain at, or near, this temperature depends, not on the time taken to pass through the machine, since during this time the seed is not remaining hot but is being gradually heated, so much as on the treatment of the seed after leaving the machine. If sacked immediately, the seed cools at an astonishingly slow rate, the temperature only falling one or two degrees per hour. If, on the other hand, the seed is exposed to the air in a thin layer immediately after treatment, the temperature may fall well below the minimum fatal temperature in less than half a minute.

The necessity for bearing these facts in mind and the difficulty of giving a satisfactory reply to the question postulated above, are well illustrated in Table I, which shows the mortality of the worms at different temperatures with various methods of treatment. The temperature in every case is the temperature of the seed immediately after treatment. A black line has been drawn on the right-hand side of every column as far as the minimum temperature which gives a regular mortality of 95 per cent or more. It will be seen at once that the tops of the black lines in the different columns vary in position from 47° to 60° C. What, then, are the causes of these discrepancies ?

In the first two columns are given the figures from some experiments in which small bags of infected cotton seed were dipped, for one minute in one case, and for five minutes in the other, in hot water at various temperatures. After treatment the seeds, being in a small mass and covered with water, cooled rapidly. It will be noticed that with the one minute treatment complete mortality was only reached at 59° C., whereas with the five minutes treatment practically all the worms were killed at 50° C. The latter temperature is probably very nearly the minimum temperature which kills the worms, which shows that the full effect of heat treatment is obtainable in five minutes.

The next three columns give the results of experiments with the Domains' experimental machine. This machine consisted of an

TABLE I. Showing Mortality of Pink Boll Worm at Different Temperatures with Different Methods of Treatment.

Temperature C.	Hot Water, 1 minute.	Hot Water, 5 minutes.	Domains' Machine, 2 minutes.	Domains' Machine, 3½ minutes.	Domains' Machine, 6¼ minutes.	Ministry's Machine, 5 minutes.	Ministry's Machine, 7 minutes.	Ministry's Machine, 9 minutes.	Simon's Machine, sacked hot.	Simon's Machine, partly cooled.	Simon's Machine, rapidly cooled.
45	—	—	48	—	—	30	—	76	—	—	—
46	—	—	—	—	72	38	—	—	—	—	—
47	—	—	—	100	76	—	—	96	—	79	—
48	—	—	84	—	—	100	97	—	—	—	—
49	—	—	68	100	—	—	—	—	72	—	70
50	48	97	76	—	—	—	100	100	—	50	—
51	—	—	—	—	—	100	—	100	94	95	35
52	—	—	—	—	—	100	—	—	96	98	49
53	—	—	96	—	100	100	—	100	100	98	69
54	—	—	—	—	—	100	100	—	100	96	83
55	92	100	—	—	—	—	100	—	—	99	—
56	—	—	—	—	—	—	—	—	100	100	81
57	—	—	—	—	—	—	100	—	100	100	83
58	—	—	—	—	—	—	—	—	100	100	76
59	100	—	—	—	—	—	100	—	100	—	78
60	—	100	—	100	—	—	—	—	100	100	97
61	—	—	—	100	100	—	—	100	100	—	99
62	100	—	—	—	100	100	—	100	100	100	100
63	—	—	—	100	—	100	—	—	100	—	100
64	—	—	—	—	—	—	—	100	100	—	90
65	—	100	—	—	—	—	100	—	100	—	99
66	—	—	—	—	—	—	100	100	—	—	—
67	—	—	—	—	—	—	—	—	—	—	—
68	—	—	—	—	—	—	—	—	—	—	—
69	100	—	—	—	—	—	—	—	—	—	—
70	—	100	—	—	—	—	100	—	—	—	—
71	—	—	—	—	—	—	—	—	—	—	—
72	100	—	—	—	—	—	—	100	—	—	—
73	—	—	—	—	—	—	—	—	—	—	—
74	—	—	—	—	—	—	—	—	—	—	—
75	—	100	—	—	—	—	—	—	—	—	—

endless band of cloth the upper half of which passed through a wooden box the air in which was heated by a number of steam-pipes. The quantities of seed delivered were so small that the rate of cooling after leaving the machine was considerably greater than it is in sacked seed from machines with a bigger output. The three columns show the results obtained with different speeds, the seed passing through the machine in two, three and a half, and six minutes respectively. In the first column the black line reaches 53° and in the second 47° C. In the third the exact point where it should terminate is doubtful, owing to the fewness of the figures, but it must be between 53° and 47° C. Complete mortality at 47° C. with a three and a half minutes' treatment is rather astonishing at first sight, since it is a better result than was obtained with five minutes' complete immersion in hot water. The explanation of this lies in the fact that the band travels very slowly and that the temperature in the middle of the hot-air chamber is much higher than that at the ends, with the result that during the final stages of its journey through the machine the seed is probably falling in temperature, while at the end of its journey it is exposed for a short time to the temperature of the outer air before reaching the collector, so that the recorded temperature is not the maximum temperature actually reached by the seed. This view is supported by the figures for the germination of the seed given in Table II, from which it will be seen that at the slower speeds in this machine the seed is badly damaged at impossibly low temperatures. A further confirmation of this explanation lies in the fact that a maximum thermometer, passed through the machine on the band at a time when the temperature of the treated seed was only 50° C., showed a maximum reading of over 100° C.

In the Ministry's hot-air machine, likewise, the seed undoubtedly is cooled down considerably from its maximum temperature before being delivered into the sack, most of this cooling probably taking place in the screw conveyor which withdraws the seed from the bottom of the machine. The conveyor is made of thin unlagged iron and exposes a considerable surface to the air, and as the seed travels along it quite slowly it has considerable opportunities for losing some of its heat. Consequently the results with it at various speeds—given in the sixth, seventh, and eighth columns—agree very closely with the results obtained in the Domains' machine.

The last three columns give the results of a large number of experiments with Simon's machine. The first of them gives the figures obtained from seed that had been sacked hot, the samples being taken more than an hour after the seed had left the machine. Here it will be seen that the mortality of the worms is very nearly complete at 51° C. and is absolutely complete from 53° C. upwards. In the second of the three columns are given the results of a number of earlier experiments in which the samples were taken as the seed left the machine and placed in small sample bags. In these bags the seed on the outside cooled rapidly, and the result is exactly what one would expect, namely, that, as in the case of the sacked seed, very nearly complete mortality is obtained at 51° C., but that odd worms survive even at 55° C. Finally, the figures in the last column show the results of cooling the seed rapidly after treatment. In this case a sample of seed was taken as it left the machine and immediately spread out on the ground. In this way its temperature fell below 45° C. in less than half a minute. The result of this treatment is very marked indeed, nothing approaching complete mortality being reached till 60° C. and odd worms surviving at temperatures even of 65° C.

We can now perhaps attempt an answer to our original question. If the seed is maintained for five minutes or more at the temperature in question, the worms are killed at temperatures from about 52° C. upwards. If, however, the seed is immediately cooled after reaching its maximum, a temperature of at least 60° C. is necessary. The temperature in both these cases is the maximum temperature actually reached by the seed containing the worms.

From this question we can now turn to the correlated question, " What is the minimum temperature that damages the seed ? " The same difficulties are met with in answering this question as in answering the former. Table II gives a similar set of figures for the germination of treated cotton seed as Table I gave for the mortality of the worms. In order to make it possible to compare the figures from different experiments in which widely different qualities of seed were used, the figures given are not the actual percentage germinations of the treated seed, but are these percentage germinations compared to the percentage germination of the untreated seed of the same sample, the latter being taken as 100. Black lines have been placed to the right of each column where the seed has undoubtedly been damaged. It must be borne in mind that as the seed used in these experiments was mostly of poor quality its germination was, very variable, and it is therefore difficult to be certain whether any individual sample has actually been damaged or not. In general, seed giving a germination of 85 per cent or less, calculated as explained above, has been considered as damaged ; but in view of the fact that one sample gave a germination 42 per cent better than the untreated seed, one cannot be absolutely certain that the seed is damaged, even when it gives a germination of only 60 per cent. When, however, the figures show a regular falling off as the temperature rises, the point at which damage begins can be more or less accurately gauged.

Table II.—Showing Germination of Cotton Seed at Different Temperatures with Different Methods of Treatment.

(The figures given are not the actual percentage germinations of the treated seed, but are these percentage germinations compared to the percentage germination of the untreated seed of the same sample, the latter being taken as 100.)

Temperature °C.	Hot Water, 1 minute.	Hot Water, 5 minutes.	Domains' Machine, 3¼ minutes.	Domains' Machine, 6¼ minutes.	Domains' Machine, 10¼ minutes.	Ministry's Machine, 5 minutes.	Ministry's Machine, 7 minutes.	Ministry's Machine, 9 minutes.	Simon's Machine, all Methods.
45	—	—	—	—	—	101	—	100	—
46	—	—	—	—	—	—	—	—	—
47	—	—	92	92	81	100	—	97	95
48	—	—	—	—	—	93	96	—	—
49	—	—	142	—	—	—	—	—	—
50	—	79			60	—	98	103	99
51	—	—	—	—	—	97	—	89	95
52	—	—	—	—	—	96	—	—	80
53	—	—	—	33	—	88	—	73	100
54	—	—	—	—	—	78	70	—	98
55	88	94	—	—	2	—	103	—	98
56	—	—	—	—	—	—	—	—	99
57	—	—	—	—	—	—	98	—	97
58	—	—	—	—	—	—	—	—	97
59	110	—	—	—	—	—	—	—	—
60	—	91	85	—	—	—	74	—	86
61	—	—	81	46	1	—	—	59	98
62	—	—	—	9	—	50	—	65	99
63	—	—	81	—	—	—	—	—	102
64	100	—	—	—	—	23	—	—	102
65	—	73	—	9	—	—	55	65	101
66	—	—	—	—	—	—	41	44	—
67	—	—	—	—	—	—	—	—	—
68	—	—	—	—	—	—	—	—	—
69	—	—	—	—	—	—	—	—	—
70	100	67	—	—	—	—	18	—	—
71	—	—	—	—	—	—	—	—	—
72	—	—	—	—	—	—	—	12	—
73	—	—	—	—	—	—	—		—
74	—	—	—	—	—	—	—	—	—
75	88	—	—	—	—	—	—	—	—

To deal with the figures in detail, it will be seen that one minute's immersion in water at 70° C. has no effect on the germination whatever, while even at 75° C. it is highly doubtful whether any damage is done, the germination actually found being the same as that found at 55° C. when obviously the seed was not damaged.

Hot-water treatment for five minutes shows a distinct loss in germination at 65° C., which is increased at 70° C. At 60° C., however, the damage is at most slight and in all probability non-existent.

In the Domains' machine three and a half minutes' treatment shows what appears to be the beginning of a drop at 60° C., but owing to the paucity of the figures it is difficult to be certain. Six and a quarter minutes' treatment, however, causes severe damage to the seed at a temperature as low as 53° C., while with ten and a half minutes the seed is damaged at 47° C. and loses its germinating powers practically completely at 55° C. In view of the results obtained with the other machines, it seems quite certain that the seed was actually raised in these cases to temperatures much higher than those recorded. The figures are therefore only significant in connection with this particular machine.

In the Ministry's machine, in which, as already explained, the recorded temperature is also too low, seed with a seven minutes' treatment is undamaged at 57° C., but is undoubtedly damaged at 60° C., while seed with a nine minutes' treatment seems to be damaged at as low a temperature as 53° C. With the five minutes' treatment a big gap occurs in the figures available at the critical point, but the drop in germination probably begins about the same point as with the seven minutes' treatment.

The germination figures from tests with Simon's machine have all been added together, since in no case has any loss in germination been found at any temperature used. No trials have been made with temperatures over 65° C., partly because all the trials were made with a view to testing the machine from the practical point of view and not with a view to finding theoretical figures for the effect of heat on cotton seed, and partly because it is difficult to obtain a temperature over 65° C. without exceeding the steam-pressure for which the machine is guaranteed.

Other machines working on principles similar to those of Simon's machine have given generally similar results, except where, owing to the too slow movement of the seed, individual seeds have been overheated through being kept too long in direct contact with the steam-jacket.

Our second question we can now answer as follows. Provided that neither the whole mass of seed nor individual seeds are heated to a higher temperature during the treatment, wet seed can safely be raised to a temperature of 60° C., and dry seed to a temperature of at least 65° C. without damaging the germination. Further, seed at these temperatures can safely be sacked in spite of the very slow rate of cooling of cotton seed in bulk.

Before passing on to a consideration of the various types of machine proposed, there are a few minor questions of general interest to be dealt with. In the first place, as soon as the question of actually erecting the machines in the ginneries arose, it was immediately asked whether the machine could be placed between the gins and the sifters,* so as to treat all the seed together instead of having to make separate arrangements for the sifted seed and the seed from the affrita-gins.* The great advantage of this arrangement is obvious, but two objections have been raised to it. Firstly, it has been suggested that the seed in *mabrûma** cotton which has passed through the gins may not get sufficiently heated owing to the insulating action of the cotton fibre. And secondly, it has been urged that if the heated seed goes direct from the machine into the sifters, the seed will be rapidly cooled and the full effect of the heating will not be obtained.

In order to test the first of these points, experiments were carried out with Simon's machine on two occasions. On the first occasion the mortality of the pink boll worm was as shown below :—

	In Ordinary Seed.	In Seed from *Mabrûma*.
	Per Cent.	Per Cent.
Control	29	28
Seed treated at 50° C.	50	73
" " 53° C.	100	93
" " 56° C.	100	100
" " 58° C.	100	100
" " 60° C.	100	100

* For the benefit of those who are not conversant with the process of ginning it should be explained that in bolls that for one reason or another have not ripened properly, the lint in one or more locks often fails to fuzz out, remaining in a felted mass round the seed. Such locks of cotton are known as *mabrûma*. They are generally thrown out by the ordinary gins with the seed, from which they are separated by the sifters. Finally they are passed into special gins, known as "affrita-gins," which tear them up and separate the lint from the seed.

On the second occasion the results were very similar :—

	In Ordinary Seed.	In Seed from *Mabrûma*.
	Per Cent.	Per Cent.
Seed treated at 49° C.	72	56
,, ,, 51° C.	94	100
,, ,, 52° C.	96	91
,, ,, 53° C.	100	100
,, ,, 54° C.	100	94
,, ,, 55–60° C.(Av.) ...	100	99
,, ,, 61–65° C.(Av.) ...	100	100

From these figures it is clear that for practical purposes the effect on the worms in *mabrûma* cotton may be regarded as the same as that on the worms in sifted seed.

The second objection to putting the heating machine between the gins and the sifters is a more serious one, as may be seen from Table I, from which it is clear that if the seed is rapidly cooled after leaving the machine a much higher temperature is necessary to ensure the killing of all the worms. The difficulty can be overcome, however, by running the treated seed into an insulated vat with a capacity equal to, at the very least, five minutes' output of seed. When once this is full, the seed should be withdrawn from the bottom at the same rate as it enters at the top. In this way every seed will remain at the requisite temperature in this vat for at least five minutes before being cooled down. If some such device is not employed and it is still decided to treat the seed before sifting it, the temperature employed will have to be higher, the exact degree depending on the rate at which the seed is cooled after leaving the machine in each individual case.

The question of controlling the temperature deserves a few general remarks. In those machines in which the seed is heated by steam-jackets or steam-tubes, either by direct contact or by radiation, the temperature of the treated seed depends on :

(*a*) The initial temperature of the seed.

(*b*) The rate at which the seed enters the machine. This is presumed to be, in the course of normal running, the same as the rate at which it leaves the machine.

(*c*) The pressure of the steam.

(*d*) The time which the seed takes to pass through the machine.

(*e*) The quality of the seed being treated.

If all these factors are constant, the temperature of the treated seed will also be constant. To take them in turn, the initial temperature of the seed will vary considerably in the course of a whole ginning season. During any one day, however, the variation will be so small as to be quite negligible. The rate at which the seed enters the machine should prove fairly easy to keep constant, either by running the output of so many gins into the machine or by fitting an effective automatic feed. With a fairly constant pressure in the boiler and a good type of reducing valve there should be no difficulty in keeping the pressure of the steam reasonably uniform. If the machine is driven off the main shaft of the factory, its rate of revolution, and consequently the speed at which the seed travels through the machine, will be constant. And, finally, the quality of the seed will only change at comparatively infrequent intervals. With such a machine, therefore, running continuously and fitted with the proper accessories, the amount of adjustment required should be very small indeed, and an automatic control is barely necessary, all that is required being an apparatus which will ring bells to warn the operator when the temperature falls too low or rises too high. Such a piece of apparatus can easily be constructed, using a pair of Hearson's incubator capsules, an air thermometer, a mercury thermometer, or any similar device for making the necessary electric contacts when the temperature rises to one point or sinks to another.

Another method of controlling the work of the foreman in charge of the machine is to keep a record of the temperature throughout the day's run by means of a thermograph. An apparatus which rings warning bells has been constructed by the Cambridge Scientific Instrument Company, and may be obtained from Messrs. Mosseri, Curiel & Co., while a very similar piece of apparatus, with the addition of a thermograph, to which a bell-ringing device could very simply be added, though not originally included, has been designed by Messrs. G. Christodoulou and A. Gyzi, of Zifta.

In those machines in which the seed is heated by a current of hot air the question of control is a more difficult one, since, in the list of factors affecting the final temperature of the seed, the steam pressure is replaced by the temperature and the volume of the air passed through the machine. The temperature of the air will itself depend on its own initial temperature, the temperature of the steam-pipes or other heating agency employed, and on the rate at which it passes over them. Of these, the two last factors may fairly easily be kept constant, but the first-named may vary very considerably in the course of an ordinary working day. It is obvious, therefore, that the amount of adjustment required will be much greater in this type of machine than in the first-mentioned type. Probably the easiest way to make the necessary adjustments is either to regulate the current of air so that the quantity of heat it carries in a given time is always the same, or to keep the current of air constant and regulate its temperature by mixing an adjustable quantity of cold air with the air from the heating chamber, which should be slightly over-heated. The regulation, if possible, should be automatic.

As regards the cost of running hot-air machines, in those in which steam is used as the heating agent, the cost may be divided under three heads :—

(1) The steam used in heating the seed.

(2) The steam lost through radiation and other causes.

(3) The power necessary to keep the machine in motion.

The first of these will vary according to the initial temperature and the quality of the seed, but is quite independent of the type of machine used. Calculation shows that to raise the temperature of one ardeb of fair commercial cotton seed from 15° to 55° C. with steam at 60 lbs. pressure requires about 8·2 lbs of steam.

The quantity of steam lost will probably vary very considerably in different machines. It should, however, always be very much less than the above figure or the machine should be condemned for inefficiency. In a trial with Simon's machine carried out by Mr. Singleton, of the Mechanical Service, the steam consumption was found to be 11·4 lbs. per ardeb, showing that 3·2 lbs. or 28 per cent of the total steam used was lost.

With the last item of expense, if all the different types of machines are considered, the variation will be very great. In those machines in which the seed is heated by direct contact with steam-jackets or steam-tubes, however, the power necessary should be fairly uniform, since in all cases it is the power required to keep the seed in a reasonably rapid state of motion. One horse-power for every four or five ardebs treated per hour is probably an average figure.

One other point of general interest to prospective manufacturers should be mentioned. Owing to the great undesirability of mixing seeds from different kinds of cotton, it is essential that the machine should be made in such a way that it can easily be emptied or cleaned out when a fresh variety of seed is to be treated.

We may now pass on to a consideration of the individual machines.

(*a*) Machines in which the Seed is heated by a Current of Hot Air.

(6) *The Ministry of Agriculture's Hot-air Machine.*—An account of this machine by Dr. Gough has been published in the Ministry's Bulletin No. 6. The seed is carried backwards and forwards through the hot-air chamber on a succession of endless bands consisting of chains of narrow transverse trays which by a device drop the seed to the next line of trays just before reaching the rollers, so that in this way the lower part of each band is utilized as well as the upper and the seed traverses the length of the machine eight times, although there are only four endless bands. At the top of the machine is a fan which draws a current of air through, and at the bottom are two doors, one leading to a chamber where the air is heated by passing over the flues of a furnace, and the other opening to the outside air. The temperature of the ingoing air, and thus of the treated seed, is regulated by adjusting these two doors.

This machine, which has an output of from one and a half to four ardebs per hour, according to the rate at which it is run, was erected purely as an experimental model. Having been found to give satisfactory results, however, it was used for treating consignments of cotton seed for export. Four hundred ardebs of seed were treated in this way for the Sudan. This seed was exceptionally free from worms and it was very difficult to find any in it, either alive or dead. After treatment, however, not a single living worm was found either in the examinations carried out in the Entomological Section in Cairo or by the Sudan officials. The results of the germination tests of the treated seed were:—

	Per Cent.
200 Ardebs *Mit 'Afifi*	
Untreated	97·2
Treated	97·2
100 Ardebs *Sakellarides*	
Untreated	95·4
Treated	95·0
100 Ardebs *Ashmûni*	
Untreated	96·9
Treated	96·7

The above figures, which show a quite inappreciable loss of germination, are based on no less than 2,400 separate tests, and so may be regarded as fairly reliable. However, for the benefit of those who are always sceptical of anything in the nature of "scientific" tests, one may mention that the seed in question has been reported by Mr. MacGillivray, of the Sudan Plantations Syndicate, to be well up to the normal both as regards germination and as regards the subsequent growth of the plants, and that careful search has failed to reveal the presence of the pink boll worm in the district in which the seed was sown.

Similar consignments of seed have also been treated in this machine for British East Africa, Somaliland, and Algeria.

Although the machine has proved very useful for experimental purposes and for treating these consignments for export, it is not to be recommended for use in ginneries, as a machine of this type with the necessary output would be a very clumsy cumbrous affair compared with some of the other types that have been suggested more recently.

For further particulars see the report referred to above or apply to the Ministry of Agriculture.

(7) *The Hess Drier.*—A modification of a machine used for conditioning corn has been proposed by an American firm. It consists of a tall rectangular tower containing a succession of oblique plates fixed alternately on opposite sides, which make the seed, which is fed in at the top, occupy a space which zigzags from one plate to another from top to bottom. While in this tower, the seed is subjected to a strong current of hot air, by which it is heated to the requisite temperature. It then falls into a second similar tower, in which it is subjected to a current of cold air, by which it is cooled down again to its initial temperature. This air, which has been used for cooling the seed and has itself been heated very considerably in the process, is then used for heating the seed in the upper tower after being passed through a chamber containing coils of steam-tubes by which extra heat is added to the system to make up for the unavoidable losses.

The machine has been in use for some time past for drying grain of various kinds, all the insects it contains being killed at the same time. For treating cotton seed successfully, the manufacturers claim to have made the necessary modifications, consisting of different types of feeding and discharging mechanism, and steam-coils of extra capacity. It might also be advantageous, for the reasons already explained above, to insert between the two towers a chamber in which the seed could be allowed to remain hot for some time before being cooled again. With such modifications the machine should prove satisfactory. It is not expensive to erect and should be the most economical of all to run, since the steam consumption is reduced to a minimum by utilizing the heat from one lot of seed to heat the succeeding lot. The manufacturers were anxious to erect a demonstration machine in Egypt, but eventually abandoned the idea owing to the difficulty of transport during war-time.

For further particulars apply to the Hess Warming & Ventilating Company, Tacoma Building, 5 N. la Salle Street, Chicago, Ill., U.S.A.

(8) *The Neumancantelli Hot-air Machine.*— An experimental model of an exceedingly ingenious machine, designed by Mr. I. Neuman, was erected by Mr. Mancantelli of the firm of Messrs. Allen Alderson & Co. It consisted of six cylinders on a revolving base, which at definite intervals was moved round by a piece of antomatic apparatus until each cylinder occupied the position occupied previously by the one next to it. The six positions represented six stages in treating the seed. In the first the cylinder was filled with seed; in the second a current of air at 30° C. was circulated through the cylinder; in the third a current of air at 40° C.; in the fourth a current of air at 50° C.; in the fifth a current of air at 55° C.; and in the sixth the seed was discharged. The whole apparatus, though the process sounds rather complicated, was so ingeniously contrived that the only parts of the whole process that needed human attention were the filling and the emptying of the cylinders. The advantages claimed for the system were that owing to the gradual heating in stages, the seed would be dried before being exposed to the higher temperatures and would therefore be less liable to damage, and also that owing to the air being at the temperature requisite for the treated seed there could be no possibility of overheating the seed. Unfortunately, in practice, it was found to be impossible to get a sufficiently rapid current of air to raise the temperature of the seed at a reasonable pace. From the specific heats and specific gravities of air and cotton seed it can be calculated

that one cubic metre of cotton seed is calorimetrically equivalent to about 1,000 cubic metres of air. It will thus be seen that it will be no easy matter to make the requisite quantity of air pass through a solid mass of cotton seed in anything approaching a reasonable time.

For further particulars apply to Mr. I. Neuman, 6, Sharia Emâd el Dîn, Cairo, or to Mr. J. Mancantelli, c/o Messrs. Allen Alderson & Co., Ltd., Cairo.

(b) Machines in which the Seed is heated by Radiation from Steam Pipes.

(9) *Domains' Machine.*—A purely experimental machine, already referred to above, was erected in 1914 by the engineers of the State Domains Administration. In this machine the seed was carried on an endless band through a long wooden box containing a number of steam-tubes by the radiation from which the seed was heated. A full description of the machine and an account of experiments carried out with it is given in the "Agricultural Journal of Egypt," 1914, Volume IV, Part II, page 115 (Storey, "Notes on Large Scale Experiment against the Pink Boll Worm in Cotton Seed").

For further particulars apply to the State Domains Administration or the Ministry of Agriculture.

(10) *Matsouchis' (Planta's) Machine.*—A machine designed by Mr. Panayoti Matsouchis, engineer to Messrs. J. Planta & Co., is being erected at that firm's ginnery at Mansûra. It consists of a series of long axles bearing radiating blades, in section like a paddle-wheel, arranged one above the other, alternate axles revolving in opposite directions. The seed falls on the rising blades of the uppermost axle, and is carried over by them as they revolve till they drop it on to the rising blades of the next axle, on which they are carried over in the opposite direction till they fall on to the rising blades of the third axle, and so on to the bottom. During the course of this journey the seed is heated by radiation from a number of steam-tubes arranged in a plane parallel to that occupied by the falling seed.

At the time of writing the machine has not yet been completed, so it is impossible to give any definite opinion as to its merits. The advantage of heating by radiation instead of by direct contact with steam-pipes is that there is less danger of overheating individual seeds. The disadvantage of it is that it necessitates a very much larger heating surface for the same output. Thus the Domains' machine and Simon's machine, in which the surface of the steam-tubes must be very approximately equal, had outputs of about one-fifth of an ardeb and fourteen ardebs per hour respectively. The heating surface of the steam-tubes in the Domains' machine was not arranged so as to give its maximum effect, but even if it were so, the difference between the two would still be very great.

For further particulars apply to Mr. Panayoti Matsouchis, c/o Messrs. J. Planta & Co., Mansûra.

(c) Machines in which the Seed is heated by Direct Contact with Metallic Heating Surfaces.

(11) *Simon's Machine.* This machine has already been referred to several times above and formed the subject of a special report in the Ministry of Agriculture's Bulletin No. 11. It consists of a horizontal cylinder which is kept nearly full of seed, which is fed in at one end and withdrawn at the other. The seed is kept continually in motion by a revolving framework which carries a number of longitudinal steam-tubes by means of which the seed is heated.

An account of a number of experiments with this machine are given in the report referred to above. Figures from later trials are given in the tables on pages 9 and 12 of the present report. As regards practical trials, as apart from scientific tests, on December 14, 1916, and the succeeding days, 100 ardebs of seed were treated in this machine by a *moâwen* from the Entomological Section who had had no previous experience of handling the machine. Twenty-five samples taken at random from the treated seed showed an average of 96 per cent pink boll worms killed and an average germination of 86 per cent as compared with 87 per cent in the untreated seed. A little experience in running the machine and the fitting of better controls should make it easy to improve very considerably on these figures. *Taqâvi* seed treated for Mohammed Bey Efflatoun and for the State Domains Administration is reported to have been quite up to the normal as regards both the germination and the subsequent growth of the plants.

This machine being originally designed as a malt-drier, a number of other types of malt-drying machines were examined by Mr. Cartwright, Inspector of the Ministry of Agriculture, while in England. None of the types seen, however, seemed to be so simple in construction and management or to meet the requirements of the case so satisfactorily as Simon's machine.

The new models of the machine are fitted with an automatic apparatus for ringing bells when the temperature rises too high or falls too low, an improved reducing-valve facilitating the adjustment of the steam-pressure, and a door in the base of the cylinder for cleaning it out when a fresh variety of seed is to be treated.

This machine has been definitely approved by the Ministry of Agriculture.

For further particulars apply to Messrs. Mosseri, Curiel & Co., 16, Sharia Nubâr Pasha, Cairo.

(12) *Lenzi's Machine.*—An experimental model of the simplest possible form of seed-heating machine was erected during March of this year in the ginnery of the Banque Transatlantique at Mansûra. It consists of a long narrow cylinder, steam-jacketed all round, in which revolves an axle bearing a number of broad propeller blades which force the seed from one end to the other.

A sample of seed treated at 55° C. showed complete mortality of the worms, but a slight diminution in the germination of the seed. The actual tests made gave the following figures for germination :—

	First Trial.	Second Trial.	Third Trial.	Fourth Trial.	Fifth Trial.	Average.
						Per Cent.
Untreated	66	46	66	71	73	64·5
Treated	62	59	63	61	54	60·1

These seem to show that about 5 per cent of the seed is damaged in the process. This damage must certainly be due to the overheating of a number of seeds that have remained too long in direct contact with the heating surface. It was observable that masses of seed in front of the propeller blades traversed the lower part of each revolution *en masse* with very little movement *inter se*. The outermost seeds of such masses would consequently remain in contact with the surface of the steam-jacket for a considerable period, as the rate of revolution was very slow. Obviously, it should be possible to overcome this defect by keeping the seed in more rapid motion during its passage through the machine.

Apart from this one remediable defect the machine was very satisfactory. In a trial the first seed that came through had a temperature of 50° C., which rose very gradually and regularly to 55° C., where it remained constant.

For further particulars apply to Mr. G. Lenzi, Director of the Banque Transatlantique, Mansûra.

(13) *Macri's Machine.* Practically identical in principle with the last machine is one designed by Messrs. Christodoulou and Gyzi and erected at the ginnery of Mr. G. K. Macri at Zifta. Instead of consisting of a single long cylinder, steam-jacketed all round, however, it consists of three shorter cylinders, placed one above the other, and steam-jacketed on the lower half only, the upper half being a lid which can be removed so as to facilitate the cleaning of the cylinders. In each cylinder there is a revolving framework which carries on its circumference a spiral band which propels the seed along the cylinder, and a number of longitudinal bars which keep the seed in constant motion, the whole framework revolving quite rapidly. The seed enters through an automatic feeder at one end of the uppermost cylinder and after passing through the three cylinders is delivered at the other end of the bottom cylinder. An automatic heat-regulator has been fitted, consisting of a mercury thermometer with its bulb in the seed chute, and its stem fitted with three electrical contacts in such a way that, as the mercury column rises and reaches these contacts, electro-magnets are brought into action and close steam-valves. When the mercury reaches the third contact the steam is cut off altogether. The installation actually erected has an output of approximately twenty ardebs per hour.

At a trial, carried out on June 14 of the current year, the machine was tested with two qualities of seed, firstly with what might be classed as good quality commercial seed, and afterwards with very low quality. With the better quality seed the temperatures of successive sacks were as follows: 55·5, 55, 56, 54, 54, 54, 54, 55·5, 54, 53·5, 54, 54·5, 53, 53·5, 54, 54, 54, 54, 53° C.

This represents a variation of 3° in the course of treating nineteen ardebs.

With the low quality seed the temperatures were much higher, there being no cause for fear with regard to the germination of the seed, and not so regular, probably owing to the variability of the seed. The temperatures of successive sacks were: 59, 56·5, 60, 63, 64, 63, 62·5, 59° C.

Leaving out of account the first two sacks, which can never be relied upon, this gives a range of 5° C.

Examination of the treated seed gave the results shown in Table III. These may be summarized as follows:—

With the good seed, treated at temperatures from 53° to 56° C., the average mortality of the worms was 99·6 per cent and the average germination of the seed was 85 per cent, that of the untreated seed being 82 per cent.

With the bad seed, treated at temperatures from 56·5° to 64° C., the mortality of the worms was uniformly 100 per cent, and the average germination of the seed was 49 per cent, that of the untreated seed being 48 per cent.

These results are sufficiently satisfactory, showing that the machine has a range of at least 12° C., over which it kills practically all the worms without damaging the seed, and as it can be made to run with a variation of not more than 5° C., there should be no difficulty in getting uniformly satisfactory results.

Experience with this model, however, has already suggested some improvements. In the first place, it is a little difficult at present to get a high enough temperature with a reasonable steam-pressure when treating seed of a good quality. This can easily be remedied by increasing the area of the steam-jackets, which at present only surround the lower half of each cylinder. In the second place, the automatic control would be improved if it were made to work on the steam-pressure in the third cylinder only. It may safely be taken for granted that the seed will not be overheated before leaving the second cylinder. If, therefore, the steam in the third jacket is cut off entirely as soon as the temperature rises above 57° C. and opened again as soon as it falls below that point, the temperature of the seed will constantly be varying around that point but could never go far in either direction, the lagging effect, which is the greatest obstacle to accurate control when the steam-pressure in the whole machine is adjusted, being reduced to a minimum.

TABLE III.

Temperature of Treated Seed.	Mortality of Pink Boll Worm.	Germination of Cotton Seed.	Temperature of Treated Seed.	Mortality of Pink Boll Worm.	Germination of Cotton Seed.
°C.	Per Cent.	Per Cent.	°C.	Per Cent.	Per Cent.
	Good Seed.			*Bad Seed.*	
53	98	85	56·5	·100	47
53·5	100	93	59	100	53
54	100	83	60	100	52
54·5	100	88	62·5	100	45
55	100	80	63	100	49
55·5	96	87	64	100	47
56	100	78	Control 1	—	48
Control 1	—	79	,, 2	—	45
,, 2	—	79	,, 3	—	50
,, 3	—	87			

This machine has been definitely approved by the Ministry of Agriculture.

For further particulars apply to the Société pour l'Exploitation de la Machine " Delta," Zifta.

(14) *Baker's Machine.*—A machine, which might prove of use in factories in which there is no steam available, has been proposed by Messrs. Joseph Baker & Sons, Ltd., of London. This, in principle, is very much the same as the last machine, but the cylinders through which the seed passes, instead of being heated individually by steam-jackets, are heated collectively in a gas-oven. It is proposed to have seven of these cylinders in each oven. The heat is maintained by transverse rows of burners lying across the interior of the oven at the top and along the bottom. The gas is delivered into these burners under pressure, a suitable compressor being provided for the purpose. Any kind of gas fuel will do. An automatic control is also supplied.

No machine of this type has yet been erected and so there are no practical data on which to base an opinion. However, there is little doubt that if the requisite size and position of the burners are found by experience, the machine should prove as satisfactory as the last machine and even easier to control, the maintenance of a steady temperature in a gas-heated machine being a very simple matter.

For further particulars apply to Messrs. Joseph Baker & Sons, Ltd., Willesden Junction, London.

(15) *The Egyptian Engineering Company's* (*Rose's*) *Machine.*—An experimental machine of a somewhat novel type has been erected by the Egyptian Engineering Company at Mansûra. It consists of a central heating cylinder surrounded by an outer cylinder, the space between the two being divided by longitudinal partitions into three sections along which the seed travels. The inner surface of the outer cylinder carries a number of oblique flanges which, when the machine is in motion, serve to propel the seed. This travels along the first section at the end of which it drops into the second, which conveys it back to the near end, where it drops into the third section, after travelling through which it is shot out and sacked. The whole apparatus revolves at about sixty revolutions per minute and the seed is kept in rapid motion the whole time.

The present model was originally designed to use the exhaust gases of an oil-engine as the heating agent. With these, however, it was found to be impossible to get a high enough temperature. The machine was therefore altered to take steam. The original cylinder was left, however, and as it was not made to withstand high pressures, it has been found difficult to get the seed hot enough, even with steam. A sample treated at 52° C. showed a mortality of the worms of 94 per cent, and a germination of 50 per cent as compared with 52 per cent in the untreated seed, showing that the machine can be expected to give satisfactory results if the details of its construction are modified so as to make it possible to reach the necessary temperatures without difficulty. The chief modification proposed by the firm's manager is the division of the space between the cylinders into five sections, thus making the seed travel the length of the machine five times instead of three. This would probably give the necessary temperatures with a steam-pressure of about 60 lbs. per square inch. The machine is said to be cheap and easy to construct, but will certainly be more bulky for a given output than most of the machines described above.

For further particulars apply to the Egyptian Engineering Company, Ltd., Mansûra.

Mechanical Cleaning Machines.

(16) *Dell's Mechanical Cleaner.*—This report would hardly be complete without a brief reference to a mechanical cleaning apparatus built by Messrs. Wm. R. Dell & Son, of London. an account of which will be found in the "Agricultural Journal of Egypt," 1914, Volume IV, Part II, page 123 (Storey, "Notes on Large Scale Experiments against Pink Boll Worm in Cotton Seed"). There is nothing to add to the conclusions arrived at there, namely, that the machine is not to be recommended for treating seed against pink boll worm, but might prove very useful in ginneries for separating a reasonably good sample of commercial seed from very poor quality stuff that can only be classed as rubbish.

For further particulars see the above report or apply to Messrs. Wm. R. Dell & Son, Mark Lane, London.

APPENDIX.

Since the above went to press, Mr. Neuman, the designer of the machine described on page 21, has submitted the design of a second machine. It consists of a vertical revolving axis bearing three hollow, circular, horizontal discs, which are heated by steam which is led into them through the axle from above. In contact with the upper surface of each disc, but attached to a separate fixed support, is a spiral guide which starts at the centre of the disc and ends at the circumference. The seed is fed into the centre of the uppermost disc, by the revolution of which it is forced round and round the spiral guide until it reaches the circumference. Here it falls into a collector which delivers it into the centre of the second disc. After thus passing over the three discs the seed leaves the machine and is sacked. The discs are about one metre and a half in diameter and revolve at the rate of about fifteen revolutions per minute. As the spiral passes round the axis seven times on its way from the centre to the circumference, it follows that the seed travels a distance of between twelve and fifteen metres on the surface of each disc.

No machine of this type has yet been completed and therefore any criticism of it must be purely theoretical. From a consideration of the design it seems not improbable that trouble may be encountered through the same seed remaining too long in direct contact with the steam-heated surface of the discs and thus being damaged. Should actual trial show that this is not the case, the machine should prove satisfactory as soon as the correct adjustments have been found to give the requisite temperature. The temperature could be controlled either by regulating the steam pressure as in other machines, or, if electrically driven, by regulating the rate of revolution. In the latter case the control could very easily be made automatic.

For further particulars apply to Mr. Neuman, 6, Sharia Emâd el Dîn, Cairo.