

Educational (1916) Department.

ORDINARY MS.

G.O., No. 962-3

DATED 12-9-1916.

33-8
Bulletin nos
24, 25, 26

[Despatch Abstract.]

Glass experiments.

Sanctioning the employment of Mr Albert
Lein on a pay of Rs 200 per mensem
for a period of six months for conducting
experiments in glass-making & report
appointment to the Govt of Burma
for information.

25!

Memo No. 1963-1 Est
7-6-16

In his letter

dated the 10th Apr
soliciting sanction
for incurring for
expenditure on ce
industrial experim
During the current
the Director of India
stated that he was
addressing the Govt
separately in reg
to glass-making ex
periment. He is request
to expedite the separ
communication pro

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5.6.16 5.6.16

27/6

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C No. 282
DEPARTMENT, 2/8/

Received



Registered..... 191

Subject.

Submitting a note on glass Experiments.

ENCLOSURE
No. <i>Encl 1</i>
Spare copies

No. *E8*

Station *Madras.*, Dated the *27th July 1916.* 19

From (Name) *M.E. Couchman Esq. I. C. S.*

(Designation) *Officer on Special Duty,*

Department of Industries.

To The Secretary to the Government of Madras,

EDUCATIONAL Department.

Sir,

3-sinfra
I have the honour to enclose a note on the glass Experiments, and to request the favour of early orders thereon.

I have the honour to be,

Sir,

Your most obedient servant,

M.E. Couchman

Officer on Special Duty.

Note on Glass Experiments, dated
the 26.7.16, by the Hon'ble Mr. N. S. Srinivasan

The original experiments in glass-making in Madras were carried out at Ennore by the late Mr. James Short and Mr. Scholl. Satisfied with the success attained by their small scale experiments and encouraged by the advice of a German expert whom they brought out from Europe for this purpose, they floated a company in 1909 with a capital of ^{Rs} 2,00,000, of which Rs. 1.60,000 were issued at once.

Four Austrian glass-makers were also brought out to put up the furnace and teach the local hands how to make glass.

In G.O. No. 677 Rev. of 2 March 1910 a free grant of — half the wood used in the Company's furnace for the first two years of its working, up to a maximum of 7200 tons for the whole period was — granted by Government. After working for some time it was found necessary to get out automatic machines for blowing the bottles, and in 1911 six bottle-making machines, an air compressor and mechanical gear were obtained from Messrs Forsters of St. Helens at a cost of £2350 cash and £ 1350 in fully paid up shares. The factory worked till November 1911, and turned out a considerable number of soda-water bottles. The output varied from 1000 to 1600 large bottles from four machines, and from 300 to 400 bottles from two small machines daily, but about half of the bottles made cracked in the annealing process. The chief difficulties met with were the cost of fuel. This was due to the fact that the furnace was not a continuous one. Work had to be stopped entirely to recharge the tank, and during this time the furnace had to be kept at the same heat as during ~~this time the furnace~~ actual working. This meant that work could be

carried on only for 12 hours out of the twenty-four, and thus the cost of fuel was doubled. The concession of free fuel was not of much assistance, as the cost of felling, freight, cart-hire &c brought the cost of the fuel up to Rs.8-8-0 per ton. 200 tons of fuel were used per month, at a cost of Rs.1600. As this quantity could have been purchased in the open market for Rs.2200, the actual help received from Government only amounted to Rs.600 per month. Another difficulty was that when the tank got low, prior to recharging, the glass-makers had to dip the pipe on which they took out the glass into the tank at such an angle that the heat ran up and burnt their hands, and the pipe itself became so hot as to make it difficult to work with. Thus the cause of failure was the furnace. About Rs.2,90,000 had been spent up to this time. In 1913 an attempt was made to raise further capital to put in a new furnace, at an estimated cost, including erection, of Rs.42000, but the shareholders declined to invest any more money in the concern and the Company went into voluntary liquidation. The whole plant and factory has recently been bought by Government for Rs.23,000. As the machines are still in good order the price paid is very moderate. I have consulted Messrs. Beardsell & Co. who were the Managing Agents, and Mr. J.O. Robinson, who was on the board of Directors, about it. They both agree that the furnace was the main cause of failure. Mr. Robinson told me that the Company made very good soda-water bottles, which Messrs. Spencer & Co used in large quantities and found perfectly satisfactory. He thinks that the experiment was abandoned too soon, and that it is "well worth a further trial".

22/8/16

at the time of the local market is estimated to
be about 100 tons. The output of the factory in
it plain bottles are made as well as soda water
bottles. The experiment has now the further advantage
of soda-water bottles which used to cost 22
Shillings a gross in Madras, now cost 18 Shillings.
Before the war, freight from Antwerp was 15/- a ton,
and though, of course, the present high rates will
be reduced after the war, he does not think that
freights or cost of production in Europe will be as
low again as they were before the war for a long
time, if ever, in addition to which there is an
ad valorem import duty of 10%.

The Director began experi-
ments on glass soon after the outbreak of the war.
The furnace was broken down, and the factory put
to rest. At first he rented the place for Rs. 100 a
month from the owner. He decided to build a
furnace, and the first furnace was constructed on
plans obtained from England, but it proved extremely
want in fuel consumption, but it was used for experi-
mental purposes, and the glass-makers learnt by the
side Company were not so good as before, and tried.
It was found that they had lost some of their skill.
He then made inquiries regarding building a trial out of Europe
could be obtained from Europe, but the furnace which
was working under the Company was found to have melted
and to be suitable at Delhi, and most suitable
glass-makers were making trial glass, a lighter shade
of glass than that used for soda-water bottles. In
the meantime the Director was continuing his experi-
ments to find out if the old furnace would give the
required heat. A temperature of 1200° was obtained.

4 48
but without the use of an excessive amount of alkali
(which added to the cost of the glass and lowered
the ^{quality} quantity) the mixture would not melt at this
temperature. The furnace was again altered, and
a temperature of 1400° was reached, and the furnace
kept working for three days and nights and 14 gross
of bottles were made, most of which passed through
the annealing process satisfactorily. The
Director thereupon decided to entirely rebuild the
furnace, and provide it with an arrangement for
pre-heating the air. This is now approaching
completion. The Director expects that the consump-
tion of this furnace will not be more than 9 gallons
of liquid fuel an hour, at 3 as a gallon, which
means an expenditure of Rs. 24-12-0 for a day of 12
hours. The old company used to use 7 tons of wood
daily, costing Rs. 59-8-0. He is confident that
he can now produce glass of good quality, but
anticipates that the chief difficulty will be in
training the labour necessary to keep the furnace
working continuously. He is not in favour of
getting out an expert from Europe at present, even
if such men were to be had now, which is improbable.

He wishes to engage for the present a man named
Klein, who has been certified to be a French sub-
ject, and ^{has} spent many years in glass works in
France. He also has a good knowledge of this
country. He wishes to engage him temporarily on
a salary of Rs. 200 per mensem to start the train-
ing of the workmen. He also wishes to begin to
enquire for an expert in England, so that if
possible one may be obtained in about six months
time, when the workmen here should be becoming
proficient. If Mr. Klein proves good enough
there may be no need to get another expert from,

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 the ~~quality~~ ^{quantity} of the mixture would not be at this
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 of liquid fuel an hour. At 3 as a gallon which
 means an expenditure of Rs. 24-12-0 for a day of 12
 hours. The old furnace used to use 7 tons of wood
 daily, costing Rs. 50-0-0. He is confident that
 he can now produce glass of good quality, but
 anticipates that the chief difficulty will be in
 training the labour necessary to run the furnace
 working satisfactorily. He is not in favour of
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 enquire for an expert in England, so that if
 possible one may be obtained in about six months
 time, when the workmen have should be becoming
 proficient. If Mr. Klein proves not enough
 there may be no need to get another expert from

England. As however, it takes a long time to find a
 suitable man, the Director may at once be authorised
 to make enquiries if such a man would be available if
 wanted.

The expenditure up to the present time is as follows-

Sept. 1914 Reconstructing the furnace	1500
Oct. to April 1915 Trying workmen	1500
April to October. Experiments with furnaces	2500
Dec. 1915 Trial of furnaces	1400
Jan. to March 1916 Experiments on composition of glass and remodelling of furnaces	2500
March and April. Second large trial of furnace	1000
May, June and July Remodelling of glass furnace	6000
	<u>16400</u>

The above expenditure includes Rs. ~~4000~~ still to be
 paid, owing to orders placed. The Director expects
 that the factory will be ready for working about
 the end of this month. The following statement
 shows the expenditure on miscellaneous Industrial
 experiments for the four months April - July 1916.

Statement of Receipts and Expenditure of Miscellaneous Industrial Experi-
 ments for four months from April to July

	Budget grant for 1916- 17.	Receipt	Expenditure.			
			Staff	Experi- mental	Capital	Total.
1. Pencil	37,000	241	400	573	..	973
2. Glass		117	304	2015	4168	6487
3. Miscell- aneous		-	-	724	-	724
Total	37,000	358	704	3312	4168	8184

* This includes
 a sum of Rs. 2,406
 being the freight
 on fire bricks
 clay and pipes
 from Jubbulpore

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26.7.1916

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officer on special duty



Registered 38 1916

Subject.

Submitting report on glass experiments.

ENCLOS RES.
No. 3 bulletin
Spare copies

No. 445 ES

Station Madras., Dated the 31st 29th July 1916.
2. 1. 8.

From (Name) K.T.B. Tressler Esq.,
(Designation) Director of Industries.

To The Secretary to the Government of Madras,
Educational Department.

Sir,

I have the honor to submit herewith my report on the glass experiments to date.

In my previous communications to Government I have indicated the general lines of the experiment and these may be briefly recapitulated.

I carefully examined the accounts of the old glass factory and made a number of enquiries regarding the way in which the industry has been conducted. These showed that the outstanding factors in production ~~are~~ were fuel and labour as is also otherwise clear. That labour can be trained is shown by the glass bottles made at the old factory which ~~even~~ ^{were} of quite good quality. Whether the men can turn out a sufficient proportion of good bottles

to spoilt ones is another question on which no evidence is available. Accounts show that the production was very much less than it should have been, but they do not show whether this was due to slow work, or an excessive proportion of wasters or defective work of the annealing furnaces. The annealing furnace is a good deal to blame as the percentage of waste here seems to have amounted to about 40 percent.

Most of old glass blowers are still in Madras but they seem to have lost a good deal of their skill which, however, may be recovered by practice. In order to test what I may term the 'labour efficiency' it is clearly necessary to arrange for runs extending over a considerable period as it would be absurd to expect the men to turn out average work until they have had at least a month's practice. Runs of this kind are rather expensive and costs can only be kept within reasonable limits by working continuously and by dealing with sufficient quantity of material to make it worth while heating the furnace at all. For continuous running three shifts are necessary. I should say that a minimum of 4 machines should be kept at work. This means 12 shifts each consisting of 4 men and a boy. Apart from this staff three shifts of neck-makers, annealers and also mechanics are required.

For the reasons already explained no regular attempt has so far been made to test the labour efficiency although a certain number of trial heats have been made to test the furnaces or the mixtures, and the material thus melted has been worked up. The results give an idea of what may be expected but the conditions of the trials were not such as to give a positive answer to the labour question.

A further reason why regular runs have not so far been tried is that the labour question comes last

in logical sequence and was therefore reserved until the last. Enquiries showed that nobody in the old factory had any definite idea of the composition of glass and it seemed desirable therefore to get some practical knowledge on this point first. The work done in this connection is generally described in bulletin 14 and most of the formulae were tested practically.

Then again, enquiries showed that the old furnaces had never been satisfactory. The fuel bill indicated great extravagance and I understand that the temperature attained did not much exceed 1150 C. This is insufficient to melt glass properly and further evidence of the inadequacy of the temperature is furnished by the character of the mixtures used as revealed by analysis. This mixture contained more than double the amount of alkali in a normal glass, obviously put in with the object of lowering the melting point. This procedure incidentally doubled the cost and impaired the quality of the glass. It was evident therefore that before any progress in respect of commercial production could be made it would, in the first instance, be necessary to evolve a more efficient type of furnace. It is this work which has taken up a greater part of the time until now.

At the beginning of the year when I submitted my proposals in connection with other industries to Government I was not in a position to give a definite reply to the furnace question and I accordingly stated that a report would subsequently be sent. About the end of May I got my first results. In a trial I maintained a temperature of over 1500 for 4 days with a fuel consumption of 9 gallons of Liquid Fuel per hour, i.e. about Rs. 1/8/- an hour or Rs. 18/- per day of 12 hours. ^{in the old factory} Fuel costs were nearly Rs. 60 for the same period.

Again, my mixture costs over Rs. 30 per ton as against Rs. 60 for the old mixture. The consumption was a great

12/ improvement on anything previously done.

The furnace in which the trial was made had been in use since the beginning of the experiment and had been chopped and changed about a good deal so that by the time this experiment was finished it was of no use for further work.

With a consumption of 9 gallons an hour ~~the~~ temperature 1500 I consider glass making to be a feasible proposition provided the labour factor proves satisfactory. I consider that a new furnace is necessary and I accordingly rebuilt the old one with proper recuperation arrangements which will probably reduce consumption still further. The question of furnaces and costs is discussed in bulletins 24 and 25.

My idea was to defer my report until the new furnace had been tested. Unfortunately, the construction took rather longer than anticipated owing to the difficulty in securing materials and is not yet quite finished. As I am vacating this appointment before the new furnace can be tested, I am therefore unable to report definitely on it, but feel convinced that it will show a marked advance on the old one.

The position is therefore as follows:-

- (a) Composition of glass has been fixed.
- (b) Furnaces have been designed which gives a sufficiently high temperature and have a sufficiently high efficiency to provide melted glass at a commercial price.
- (c) The working up of the glass has been tried on a number of occasions and results are promising—of course, it was not expected that they should be entirely satisfactory.

It may accordingly be said that all the preliminaries have been settled and that (except outstandings) no further capital expenditure is necessary to put the factory into working order.

All that remains to do now is to make an extended trial in order to ascertain the character of the labour factor. As already explained, large ^{scale} trials will cost money and I do not think it is of use trying anything of

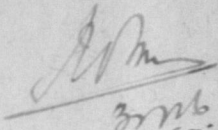
13/ this kind unless we are prepared to spend at least Rs. 1,000 a month for, say, six months. During the first month I do not anticipate any corresponding receipts, but after the third month, if the experiments are at all satisfactory, I should expect receipts to outbalance the expenditure. But, whether this proves the case or not, I am of opinion, that a six months' trial is imperative in order to arrive at a final conclusion regarding the glass industry in India. I accordingly recommend work to be carried on for the next six months at a cost of Rs. 6000 (excluding Expert.)

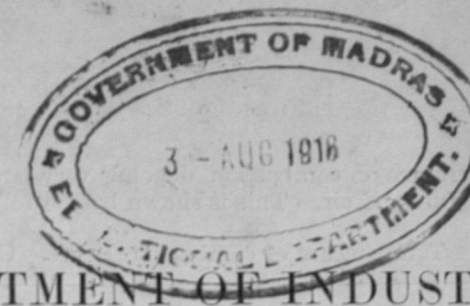
The expenditure during the year has been about Rs. 3000 and total to date Rs. 13,000. Mr. Couchman in his letter has submitted proposals for the appointment of an expert, and I need not enter upon this question here.

I have the honor to be,

Sir,

Your most obedient servant,


Director of Industries.



DEPARTMENT OF INDUSTRIES.

Bulletin No. 24.

GLASS FURNACES.

Compared with its price in other parts of the world, the cost of fuel in India is extremely high. For industrial purposes, for instance, coal may often be obtained in England at Rs. 6 a ton and coal slack at anything down to Rs. 2. Of course, these prices prevail only near collieries but then fuel industries naturally group themselves round the centres of fuel supply. In Madras city the cost of inferior coal is between Rs. 13 and Rs. 16 a ton. Upcountry it may amount to anything between Rs. 15 to Rs. 25. Firewood varies enormously in price. Upcountry, it usually ranges from Rs. 6 to Rs. 8; in cities like Madras it costs somewhere about Rs. 10 to 12.

The calorific value of Indian coal may be taken at about 9,000; that of wood at about 6,000 and that of oil at about 18,000 to 19,000. In large towns like Madras therefore there is nothing much to choose between the different kinds of fuel so far as their calorific value is concerned: they all cost somewhere about Rs. 20 per ton of fuel of 10,000 B.T.U. value. For purposes of comparison it is convenient to assume calorific values at something higher than their actual values. Roughly it may be said that liquid fuel yields 20,000 B.T.U., coal 10,000 and wood 6,666 per lb.

The present bulletin deals only with the case where fuel is employed with the object of obtaining a high temperature (as in a furnace) and not for heating purposes (as in a boiler). When the main object is the attainment of a high temperature, we have to consider not only thermal values but also temperatures of combustion.

Any of the above fuels can be used either directly or in the form of producer gas.

The gasification of wood or rather charcoal, is a fairly simple matter, but coal-gas or oil-gas require special apparatus: the losses moreover are considerable and in the absence of a market for the bye-products the gasification of the latter fuels would scarcely pay.

Wood yields a gas having a thermal value of about 125 B.T.U. per cubic foot and with careful gasification as much as 90 c. ft. gas per pound fuel have been obtained, but the figure more usually ranges in the neighbourhood of 60.

[PRICE, 1 anna.]

The temperature of combustion depends very largely on the correct proportion of fuel and air. This is shown by the following table:—

Temperature of combustion Degrees Cent.

Fuel.	With correct air.	With 50% excess.	With 100% excess.	With 200% excess.	Air required per pound fuel.
Oil	2,800	1,950	1,475	1,000	15.45 lb.
Coal	2,550	1,800	1,375	950	11.9 "
Wood *	2,000	1,450	1,100	850	5.0 "
Wood-gas	1,450	1,150	900	725	1.1 (.065 lb.)

* Air dried.

The principal cause of the reduction of temperature with added air is the cooling effect of the excess air drawn in. This may be counteracted to some extent by pre-heating the air. Regarding this more will be said later.

From this table it is to be inferred that wood-gas is not of much use when high temperatures are required, and this is one of the facts that the old Madras Glass Factory discovered from experience. The melting point of glass depends very largely on its quality: the better the glass the higher the temperature. In order to ensure a uniform melt it is necessary to be able to exceed the melting temperature by at least 200 degrees when required. A very cheap and common sort of glass requires a temperature of 1,100 °C to melt, and better grade glass goes up to 14 or 1,500 °C. To have any latitude at all in the question of melting therefore it is necessary to be able to attain a temperature of at least 1,500 °C at will.

Had the old glass furnace been properly regulated it would have been a matter of the utmost difficulty to reach the temperature required. As it was, an excess of air was usually allowed which prevented the temperature from rising above 1,200, and even this temperature was often maintained with difficulty. The result was that the glass did not melt properly and expensive fluxes were resorted to in order to increase its fluidity or else the proportion of carbonate was increased. The formula that was being followed during the last stages of the glass factory contained double the amount of alkali that any ordinary form of glass contains. The result was that the cost of the raw material was doubled and the strength of the glass enormously reduced simply in order to make it melt.

From what has been said it is evident that suction gas in this country at any rate, cannot be regarded as a satisfactory form of fuel for the attainment of high temperatures. The use of wood direct is open to similar objections and the choice accordingly lies between coal and oil. Since the price of the two on a basis of thermal units is much the same, oil is to be preferred for two commercial reasons: first because the

quality is more uniform, and secondly because the efficiency of combustion is usually greater. Oil fuel possesses a further advantage over coal because it requires less labour to look after, and is much cleaner to handle. On the other hand the efficient management of oil furnaces is a thing requiring a good deal more skill than the stoking of coal.

Taking all things into consideration, oil appears therefore, to offer the greatest advantages and was accordingly adopted as the standard fuel for experimentation purposes.

In order to ensure combustion, oil has to be atomized and this is done in various ways. In some cases the oil is atomized by means of an air blast which at the same time supplies the greater part of the air required for combustion. In this case the air pressure is low, say 6 to 8 inches of water. In the second method the oil is sprayed in by means of air at a higher pressure, say 2 to 5 lb. per square inch which supplies only a part of the combustion air, the rest being otherwise obtained. In the third method the oil is forced into the furnace under very great pressure and the whole of the combustion air is independently admitted.

The comparative trials made proved all the methods to be reasonably satisfactory. The third, namely high pressure oil, seemed the most promising, but this method if applied on a commercial scale, requires a somewhat complicated plant, which is not available. The method therefore had to be reserved for further investigation later on. In the first method, a very large quantity of air at a comparatively low pressure is required. Considerable difficulty was experienced in driving the air into the furnace through the air passages and ports and, generally, the pressure required at the blower in order to give the necessary pressure at the burner was one which could not be obtained by an ordinary fan. By using a compressor the pressure could easily be reached but the quantity required would necessitate the use of an enormous machine. These difficulties are not insurmountable, but as funds were limited and time was important, the first method was reserved for further examination also and the second method adopted throughout the trials.

A simple calculation shows that theoretically the heat required to warm the furnace to the temperature of ordinary glass is very nearly as much as that required to melt the glass in a 7-ton tank furnace such as was experimented with. The radiation loss theoretically amounts to about 5 per cent of the heat necessary to warm up the furnace. These figures are of course approximate. In actual practice convection currents will enormously increase the radiation loss. To reduce the case to actual figures, we may say that theoretically the heat required to warm the furnace is 5 million units: to melt the glass, 7½, whilst the radiation losses are ¼ million units. If we suppose that the charge is to be worked in one day, then the total amount of heat used up altogether is 18½ million units of which about one-fifth or about 27 per cent represents the heat required for the furnace itself. Now if the furnace is let down and again charged, the whole of this heat is lost. If, on the other hand, the furnace is kept hot and a new charge is constantly being fed into it, the heat loss on the furnace remains constant at its initial figure and a considerable saving in heat is therefore effected. If for instance by continuous working, the furnace is kept going for 14 days, then the total number of heat units utilized will be rather less than a hundred of which only 5 per cent

represents the heat in the furnace or loss if the furnace is let down. By continuous working, as it is called, we can therefore expect to effect considerable fuel economies.

Again a gallon of oil requires about 2,000 c.ft. of air for complete combustion. This volume of air rushing into the furnace at atmospheric temperature naturally tends to cool it. It therefore causes not only a fall in temperature but also abstracts a good deal of heat from the furnace. The theory of heating is too complex to enter upon here. It may be stated briefly that the object of furnace design should be to introduce fuel at its maximum possible entropy and to transfer the contained heat with the minimum loss of entropy. The introduction of cold air causes a loss of entropy which can be partly avoided by pre-heating and is therefore scientifically unsound besides being practically wasteful.

When the hot gases leave the furnace, they are still at a considerable temperature but are of no further value for furnace purposes. They represent a considerable source of heat and it is clear that they should, if possible, be utilized. The obvious way in which this waste heat can again be usefully employed is by pre-heating the combustion air.

The essentials of our proposed furnace are accordingly (a) to be capable of continuous working, (b) to have the combustion air pre-heated, (c) to utilize the exhaust gases for the purpose. Whilst preliminary experiments were being carried on in furnace construction, enquiries were made in several quarters regarding the details of furnace design. It was however found that oil furnaces were practically unknown in England (which is not surprising in view of the difference in cost between coal and oil in that country) and that existing designs, although of the continuous type, did not provide for pre-heating. The ordinary form of pre-heating gas furnace, such as was used in the old Madras Glass Works, is a double-ended one, the same ports and adits being alternately used as exhaust or inlet channels. Such an arrangement cannot be adopted with oil because oil is fed in the form of a liquid and leaves in the form of a gas and the passage ways are not therefore interchangeable. Further, the double-ended arrangement does not permit of continuous working and tends to establish uniformity in temperature all over the furnace which is exactly what is not required in glass furnaces.

The melting of glass may be divided into three stages, namely, the incorporation of the mixture, clearing the glass and the working. In the first stage, the mixture is heated up from cold to, say $1,000^{\circ}\text{C}$ about which temperature it begins to melt. Then it passes into the second stage when its temperature is raised as rapidly as possible and as high as possible. The glass thus becomes very fluid and the impurities and air bubbles are separated out. In this condition the glass is much too hot to work and it is therefore important, that after the third stage its temperature should be allowed to fall to a certain point. In a continuous furnace, therefore, we require three zones: a zone of rising temperature where the mixture is melted, a zone of high temperature where it is cleared and a zone of rather lower temperature where it is worked. To obtain such zones, the furnace must be unidirectional, this being also a condition for continuity. The experimental furnace first constructed was quite continuous by attaching a feeding hopper to the cold end and attempts were also made to pre-heat. The adaptation of the ordinary

system of pre-heating to single-ended furnaces necessitates the use of a large number of valves and flues. Experiments were made with such an adaptation, but, all proved unsatisfactory and that for two reasons: first because the complicated valve and channel arrangement interferes with the draught and secondly because several of the valves are exposed to a very high temperature which, if of ordinary pattern, they cannot resist for any length of time. The second difficulty was to a large extent overcome by a water-cooled valve with a fire-brick face and the difficulty of passage resistance was overcome on the inlet side by using a forced draught. On the exhaust side, however, natural draught had to be depended on and, although a chimney 80 feet high was employed it was found impossible to obtain a sufficient draught to make the flame burn brightly.

There is, however, another system for pre-heating, called recuperation which, though not as efficient as the ordinary regenerating system, is much simpler to work. In a regenerator there are two similar chambers filled with fire-brick, the admission air passing through one and the exhaust gases through the other. As therefore the one is cooled, the other is heated. At the end of a certain period the flow is reversed, the air passing through the chamber previously heated by the gas and the gas passing through the chamber previously cooled by the air. Heat transference takes place by contact. In a recuperative system, the exhaust gases pass in or round pipes, round or through which the admission air circulates. The transfer takes place through the material of the pipe and is not therefore as perfect as in the case of a regenerator, but there are no working parts and the system is therefore much more convenient to work.

The construction of recuperators involved a hunt for suitable fire-bricks and whilst the details were being elaborated, further experiments were continued with the furnace itself, using it for the time being as a non-pre-heating one. These experiments revealed various mechanical difficulties which were successively remedied as far as possible until the furnace shown in the appended sketch was at last evolved.

The two important mechanical features to be secured in an oil furnace are (1) preventing the flame from striking straight through the furnace and (2) providing a heated surface for the oil to spray on to and burn. In the design now adopted, the oil strikes upwards on to the crown of the furnace, whence it is deflected into the middle or hot zone. This deflection helps the flame to spread and prevent its striking straight through the exhaust ports. As a further precaution, a brick arch is introduced near the back of the furnace and this serves also to support the hopper. The exhaust gases passing under the arch strike up over the mixture and melt it. After that, they pass through the exhaust ports and up the chimney.

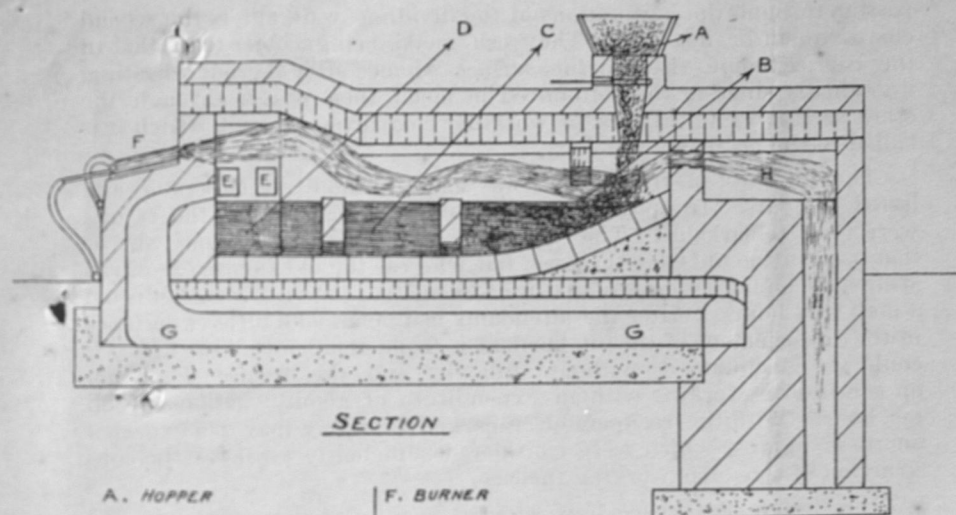
The body of the furnace is divided by two lateral partitions into three parts. The partitions are pierced by holes at the bottom but are solid above and are built to such a height as just to exceed the maximum depth of metal in the tank. The last compartment is the metal compartment and into this the charge is delivered from the hopper. It first of all falls on to a slightly elevated and sloping platform down which it slides as it melts and falls into the back end of the tank. As the metal becomes more fluid, it sinks to the bottom and,

passing through the perforations of the dividing wall, enters the second compartment or hot zone. The fresh metal, being cooler than that in the compartment, rises to the surface whence after thorough heating, it gradually sinks to the bottom. The metal then passes through the other partition into the first or working compartment from which it is ladled in the ordinary way.

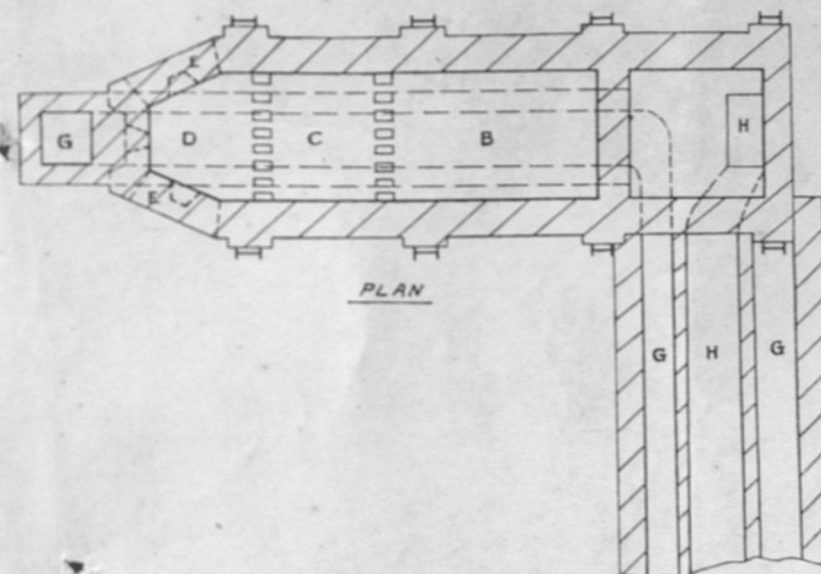
The first test of the furnace was made without a recuperator and lasted 72 hours. In spite of a considerable wastage of heat, the results were very remarkable. The furnace is of practically the same size as that used in the old Glass Factory, but whereas the old furnace required at least 24 hours before the mixture was melted, the oil furnace effected a melt in 7 hours. After the attendants had obtained a little experience in the management of the oil burners, a flame temperature of $1,500^{\circ}\text{C}$ could be maintained without difficulty and the furnace kept hot on continuous working with an expenditure of about 9 gallons of oil per hour. With the recuperator, a marked economy may be expected on these figures, which were considered sufficiently good for the construction of a regular working furnace.

The design of furnace now adopted is illustrated in the appended sketch.

STANDARD DEPARTMENTAL FURNACE



- | | |
|------------------------|----------------|
| A. HOPPER | F. BURNER |
| B. MIXTURE COMPARTMENT | G. AIR PASSAGE |
| C. MELTING " | H. FLUE |
| D. WORKING " | |
| EE. WORK HOLES | |



DIRECTOR OF INDUSTRIES
MADRAS

DEPARTMENT OF INDUSTRIES.

BULLETIN No. 25.

GLASS MANUFACTURE.

Preliminary Investigation.—The method followed by the Department of Industries in the investigation of industrial problems has been fully described in Bulletin No. 9. The standard adopted is what is termed the minimum commercial scale of production, i.e., the smallest scale on which regular factory working is likely to pay. Costs are worked out on this scale and set against probable receipts. In order to reduce the variables as far as possible, fixed charges are first of all worked out and are subsequently allowed for in calculation as a fixed percentage.

The three factors affecting prime costs, viz., raw material, technical control and manufacture are then investigated together with questions of market. From these investigations and the results of small scale trials certain costs are deduced from which it is possible to form a preliminary opinion on the financial prospects of the industry. This is termed the preliminary investigation and is the farthest point to which investigation can be carried short of actual manufacturing trials.

Applying this method to the Glass Industry we may first of all roughly determine what the minimum commercial scale of production and the fixed charges are likely to be. In the particular case of the Glass Industry, the minimum commercial scale is equivalent to an output of about 2 lakhs worth of glass annually. On this scale, fixed charges work out as shown below, repairs and renewals being included for the sake of convenience, although they should more properly be included under prime costs.

The amount of fixed charges is shown in the following table :—

—	Capital cost.	Interest at 4 per cent.	Deprecia- tion.	Total.
	RS.	RS.	RS.	RS.
Plant	75,000	3,000	6,000	9,000
Buildings	75,000	3,000	1,500	4,500
Working	1,50,000	6,000	...	6,000
Total, Capital ...	3,00,000	...	...	19,500
Repairs, say	...	...	...	3,000
Renewals	...	...	...	5,000
Staff—				
1. Works manager at	Rs. 600	...	600	
2. Assistants at...	Rs. 100	...	200	
1. Accountant and Storekeeper	Rs. 150	...	150	
1. Chemist and Mixer	Rs. 100	...	100	
			1,050 per mensem = ...	12,500
			Total ...	Rs. 40,000

[PRICE, 1 anna.]

The maximum possible outturn of a factory of this size on a 25-day month will be about 250 tons per month on continuous working or 125 on discontinuous working. The calculation is based on the production of large bottles: with small articles the figure may be reduced by anything up to 50 per cent. On the other hand smaller goods fetch a higher price than large ones and the average value of outturn will be much the same. The value of large bottles may be taken at Rs. 150 a ton, and the value of the maximum possible outturn will therefore be in the neighbourhood of 4½ lakhs with continuous working or 2 lakhs with intermittent working. On these figures the fixed charges amount to 8 and 16 per cent, respectively.

There is a glass factory in Madras which is rather smaller than the size just described. It will require the same staff, but has a maximum capacity of only 3 and 1½ lakhs, respectively, on continuous and intermittent work. The capital charges will be somewhat less and fixed charges may be estimated at 10 and 20 per cent. In the above calculation it is estimated that the plant is worked to the utmost of its capacity.

On a normal outturn the figures are increased to 15 and 30 per cent. With all the units in use and the plant only working half time the percentage of fixed charges is doubled. In actual work it is unlikely that all the units will be in use, but while work goes on it is likely to be continuous. With half the units running two-thirds of the time, the percentage of fixed charges will be about 40. Assuming that fixed charges and prime costs together are just equal to the selling price, the relation of fixed charges to prime cost will be 40:60 and this relation may be adopted for calculation purposes.

So far as practical considerations are concerned the glass problem resolves itself into this—

(1) *Raw material*.—Can we get sufficient material of suitable quality to produce 2 lakhs worth of glass annually?

(2) *Technical control*.—Have we the necessary knowledge of principles to produce the kind of glass required by the market?

(3) *Manufacture*.—Have we the practical skill to produce glass of suitable quality and finish?

Raw Material.—Under raw material are included sand, carbonate of soda and lime, to which must also be added the fuel required for melting purposes. For cheap quality glass, ordinary sand is good enough and this can be obtained by shovelling outside the factory door. Better quality sand may be obtained from Ennore, a distance of about fifteen miles, at a cost of about Rs. 5 a ton. Lime of suitable quality is available in large quantities in the Madras market at a cost of about Rs. 20 per ton. Carbonate of lime has to be imported and costs Rs. 80—100 per ton.

The other chemicals used in glass manufacture have to be imported also, but they are only used in small quantities, and need not, in preliminary calculation, be taken into account.

The original factory worked with wood fuel. This did not prove particularly satisfactory; coal is expensive in Madras and so, on the whole, oil fuel is to be preferred. Under normal circumstances the price of oil is about Rs. 40 a ton at which figure the cost of oil fuel in Madras unit for unit, is considerably higher than that of coal in England. There seems however no prospect of obtaining a material reduction in fuel prices and the only way to reduce fuel costs is to exercise the utmost economy.

Technical Control.—When the Madras Glass Factory was taken over, no one seemed to know anything about the physical properties of glass or its composition or synthesis. It became necessary in the first place therefore to obtain information on these subjects. Glass formulæ had to be obtained from various sources, and practically tested: scientific observations had to be made on the physical properties of glass, the effect of variations in composition determined.

These experiments have been carried out with the assistance of the Professor of Chemistry at the Presidency College and are described in bulletin. Unfortunately the departmental supervisors appointed to this work—about three have been tried—have all been found unsatisfactory, so that there is at present no subordinate in this department who possesses any technical training in glass. The information in the possession of the Director and the Professor of Chemistry is however considered sufficient to warrant a start. Later on a practical expert may be required.

Manufacture.—Manufacture falls into two parts, viz., the melting of the glass and the working of the glass. As regards the first point it appears from the records available, that the fuel consumption of the type of furnace constructed by the former company was so great as to preclude any hope of remunerative manufacture, except possibly on a very large scale. Before therefore proceeding to consider the process of actual manufacture, a systematic study of furnaces was begun. This investigation is described in a separate bulletin. Experiments are not yet complete but even with the present imperfect furnaces, experience shows that the fuel consumption can be kept down to Rs. 2-8-0 an hour inclusive. On longer runs the figure can be reduced to Rs. 2. These can be regarded as outside figures and are sufficiently good to justify operations being undertaken on a larger scale.

As regards actual manufacture it is evident that work once begun must be kept going continuously for a certain period, which means that three shifts have to be employed. There being six machines (two double), eight machine units are required for every shift or 24 altogether. If the number is reduced, the outturn of glass is correspondingly reduced, but the cost of fuel remains the same. If on the other hand the full number of workmen are employed, 24 machine units have to be paid for doing nothing every time there is a stoppage. This and the fact that men can only be trained to machine work when the furnace is actually in operation constitutes the principal difficulty in glass manufacture. There is direct evidence to show that satisfactory workmen can be trained but the training of such men is expensive and, during the initial stages when work is intermittent, their retention is expensive. Further the men themselves, after training, frequently run away, or else demand exorbitant payment. Experiments have been made with the material melted during the trials of the different types of furnaces experimented with and so far as the mechanical side is concerned, the results obtained may be regarded as satisfactory. But small scale experiments cannot possibly tell us how long it will take to train men, and whether they will remain when trained, nor do these experiments tell us what the relation will be between stoppages and working days. Accurate information on this point can only be obtained by actual manufacture.

Coming now to costs, the actual cost of raw material is the smallest item in the bill, and runs out at about Rs. 30 for superior glass and about Rs. 25 for inferior glass. The cost of miscellaneous labour may be estimated at Rs. 2 per ton on a large outturn and Rs. 5 on a small

one. The cost of fuel per ton obviously depends on the production. The latest type of furnace designed can furnish a continuous supply of about 4 cwt. of glass an hour. This means that, if work is continuously carried on, the fuel costs per ton will come to about Rs. 10 on a monthly outturn of about 100 tons. On 200 tons it should be possible to cut down oil consumption to about Rs. 8. Breaks in continuity reduce the outturn but do not very greatly increase fuel consumption unless they are frequent. Assuming that work is done in the most economical way possible, we may work out costs as follows :—

TABLE I.

Production	200	100	50	25	15	10	5	2	1
Fuel cost	8	10	15	20	26	40	70	100	180
Material and miscellaneous labour.	27	27	27	29	29	30	32	35	45
	35	38	42	48	55	70	102	135	225

As regards machine labour this may be calculated as follows : The unit for one machine is one blower, one gatherer, and two boys, costing about Rs. 2-4-0. To keep one machine busy three such units are required costing Rs. 6-12-0 per working day or say Rs. 170 per month.

Payment is made on a fixed basis, calculated on a maximum outturn of '3 to '6 of a ton of glass per day, according to the size of article made. Extra outturn is paid for at special rates. For the purpose of cost calculation we may consider the minimum basis throughout. The results will be safe.

The outturn of small articles is less than that of large ones; the prices obtainable are however correspondingly higher and as first approximation, we may calculate on a soda water bottle outturn. Of such, the total outturn on a 25-day month and the minimum basis will be 15 tons per unit or allowing 25 per cent breakages, 12 tons of finished glassware. We thus arrive at the following labour figures :—

TABLE II.

Cost of machine labour on rated capacity.

Number of units.	Total cost.	Maximum nominal capacity of machines.	Rated capacity per month.		Cost.									
	Rupees.	Tons.	Continu-ous. Tons.	Dis-contin-u-ous. Tons.	Monthly production in tons.									
					200	100	50	25	15	10	5	2	1	
1	170	40	12	6	...	...	...	...	(11)	17	34	85	170	
2	340	80	25	12½	...	...	(11)	12	22	34	52	170	340	
3	510	120	37	18½	...	...	(11)	21	34	51	102	225	...	
4	680	160	50	25	...	(11)	(11)	27	46	68	136	...	...	
5	850	200	62	30	(11)	(12)	17	34	56	85	...	...	...	
6	1,020	240	75	37½	(11)	(12)	21	42	68	102	...	...	...	
7	1,120	300	92	46	(11)	(13)	25	50	82	...	...	...	...	
8	1,360	360	100	55	11	15	29	58	95	...	...	...	...	

For production over rated capacity add Rs. 7 per ton.

Figures above rated capacities shown in brackets.

The total prime cost is to be obtained by adding the proper figures in table I and table II.

It will be observed that the prime cost varies enormously between about Rs. 44 per ton on large scale manufacture and Rs. 180 when the outturn is only 5 tons. In the former case the total cost, including fixed charges, is about Rs. 75 per ton, in the latter it runs into four figures.

Market.—The imports of glass into Madras are as follows :—

2½ lakhs.	Sheet glass.
5 "	Plate glass.
10 "	Bottles (at least 10 major varieties).
15 "	Soda bottles.
14 "	Phials and glass tubes.
19 "	Lampware (at least 25 varieties).
87 "	Bangles (at least 20 varieties).
6 "	Table glass (at least 10 major varieties).
28 "	Beads.

It is probably impracticable to deal with more than one or two classes of glassware, at any rate to begin with. The factory is not likely to capture the whole market and it is unsafe therefore to rely merely on a soda water trade. Combined with lamp chimneys, the demand is probably large enough to keep the factory busy. Bangles are more difficult to make but may be added later. Fine tableware may be eliminated as beyond the capacity of the workmen.

It is extremely difficult to calculate values on a mixed outturn and it will be convenient and safe to work on a soda bottle standard. The normal wholesale rate for soda bottles is Rs. 18 per gross for splits and Rs. 23 for full sized bottles. Of the latter, about 8 gross go to the ton. The value is therefore Rs. 184, say Rs. 180 per ton.

From the preliminary investigation therefore, we find that, on calculated costs, there is a good margin provided that work can be maintained with reasonable regularity. But, as has been explained in the bulletin dealing with cost calculation, figures of cost obtained by small scale experiment are merely qualitative and cannot be accepted until confirmed by production on the experimental scale. The personal equation—the reliability of the workmen—can only be tested by similar means.

All that this preliminary investigation can demonstrate is that, under suitable conditions, glass manufacture will probably pay. Whether these conditions or anything approaching thereto can actually be attained in practice is a question that actual trial on an experimental scale alone can decide.

On the experimental scale the outturn must be about 75 gross a month. On such a scale the working expenses to cover prime costs only will be about Rs. 1,500. This sum should be covered by receipts, but on this point no assurance can be given. To test the glass problem therefore it is necessary to risk Rs. 1,600 a month for a period of 10 months or so, on working expenses alone, excluding any expenditure that may be incurred on capital or supervision. Without experimental manufacture the investigation of the glass problem cannot be carried beyond the point indicated in this note.

DEPARTMENT OF INDUSTRIES.

Bulletin No. 14.

FORMULÆ FOR GLASS.

Glass cannot be said to possess a definite chemical composition, but generally speaking it may be described as a double silicate of sodium or potassium with lead or calcium. Potassium salts are now rarely used as they cost much more than sodium salts and possess no counter-balancing advantages, and though potassium nitrate still appears as an ingredient in some formulæ, its function is to act as an oxidising agent and destroy carbonaceous or organic matter rather than to act as a source of alkali. For the latter purpose, carbonates or sulphates are exclusively employed—carbonates by preference—sulphates being used only for the sake of cheapness. When employed, they must be associated with charcoal to reduce them. In place of sodium or potassium, barium is sometimes used.

The source of silica is invariably sand.

Lead or calcium act as fluxes and also impart certain distinctive properties to the glass. Lead gives a low melting point with high density and great brilliance. Lead (or flint) glass is much used for scientific and decorative purposes, but is very expensive. For fluxing purposes, about 10 per cent lead oxide suffices, but up to 35—40 per cent is often added to give character to the glass. All percentages are stated in terms of sand content. In place of lead, zinc is sometimes used.

Lime diminishes the liability to crack and gives some brilliance, which is however inferior to that imparted by lead. For fluxing purposes, up to 10 per cent may be used, but here also a considerable excess is often given in order to secure the special properties which lime confers. An excess of lime however raises the melting point, attacks the furnace and deteriorates the quality of the glass. Up to 35 per cent is permissible.

As a flux, borax is often used, especially when much alumina or clay is incorporated in the glass. The latter ingredient gives a very resistant glass of high melting point and a powerful flux like borax is therefore required to make it melt. As borax is very expensive, it is only used when special properties are required.

Oxide of iron is really an impurity, but it acts as a flux. It colours the glass green and lowers the melting point.

We see therefore that glass consists essentially of a base, viz., sand, an alkali, being a carbonate or sulphate of sodium (and rarely potassium or barium) and a flux, which is an oxide of lead, calcium or iron, and, in special cases, borax.

In addition to these primary ingredients, others are often added.

Clay or magnesia make glass hard and resistant and greatly raise the melting point. The combined proportions of these ingredients may amount to 15 per cent, but in ordinary glass they are rarely found.

Potassium nitrate is introduced as an oxidising agent to eliminate carbonaceous matter or reduce colour, usually in small proportions, say up to 5 per cent, though in a few special formulæ the percentage rises to 20. In such a case, it may be regarded as a part of the alkali ingredient. The effect of mixing a potassium salt with a sodium salt is to lower the melting point.

Arsenic or antimony are also used as oxidising agents in small proportions—usually under 5 per cent though in one formula 12 per cent is allowed.

Charcoal is added to reduce sulphates when present. Ten per cent of the weight of the sulphate (sodium) is usually allowed.

Calcium Fluoride is used in high grade glass as a flux.

Oxide of magnesium is added to reduce colour.

Glass in which lead oxide occurs is called flint glass: that in which lime is used, crown glass. Flint glass is employed chiefly for optical purposes and the very highest class of table ware. It need not therefore for the present be considered. In the following note only lime glass will be considered.

The term crown glass is, strictly speaking, applicable only to the superior varieties of lime glass. Inferior varieties are usually termed semi-white glass and bottle glass.

Bottle glass is made from the cheapest ingredients obtainable, such as, kelp, soap makers' lye, etc. In countries like India where cheap waste products are not obtainable and the alkali has to be purchased in a fairly pure form, it seems doubtful if it would pay to attempt the manufacture of bottles except where special properties are required and special prices are paid, e.g., soda or champagne bottles. Champagne bottles belong to the bottle glass category but soda bottles belong rather to the semi-white category.

Under existing conditions, the manufacture of glass of the semi-white variety is probably the most generally satisfactory both as regards working and subsequent disposal. Glass of this kind is composed essentially of sand, alkali and lime within the following limits:—

Sand	...	...	100
Alkali (S.C.)	...	...	26—37
Lime	...	...	20—35

Theoretically 100 parts of sand require 33 parts of alkali (expressed as sodium carbonate) for complete combination. Theoretically also the proportion of fluxing oxide (expressed as lime) should be 7—20 per cent. In actual practice, however, these proportions vary greatly. Lime is also an alkali and the proportion is often increased to take the place of the sodium salt. Again a reduction in alkali makes a much more resistant glass and when such a glass is required, the alkali content is reduced. To make such a glass melt at a reasonable temperature, it becomes necessary to increase the fluxing constituents and borax is usually added.

As the alkali content is reduced, the quality of the glass is improved and the other ingredients are employed in purer form. Superior glass of this kind is called *Crown glass*. There is no sharp line of demarcation between *semi-white* and *Crown glass*.

Since the alkali ingredient evaporates rapidly in the heat of the furnace, it is usual to add rather more than the quantity actually required. For this reason it is necessary to differentiate between formulæ for glass manufacture and analyses of glass: the latter always contain less alkali.

As already explained potassium salts were formerly largely employed but laterly they have gone almost entirely out of use and sodium salts, either the carbonate or the sulphate, are almost invariably used. In the following formulæ, both salts are termed "alkali," the carbonate being designated S.C. and the sulphate S.S. The two are interchangeable, 53 parts of the carbonate being equal to 71 parts of the sulphate, but when sulphate is used, about 5 per cent of charcoal must be added to reduce the sulphur radical.

BOTTLE GLASS.

The following analyses of French bottle glass indicate the general composition of this class of bottle, which is strong and tough:—

Sand	...	...	...	100	100	100	100
Alkali (S.C.)	...	...	...	5	5	10	15
Lime	...	...	...	30	37	31	40
Charcoal	...	...	...	Nil.	Nil.	Nil.	Nil.
Clay	...	...	...	11	12	5	6
Iron	...	...	...	7.3	6.7	4.3	4.0

For ordinary bottles the following formula has been recommended:—

Sand	...	100	Salt	...	...	9
Alkali (S.C.)	...	13	Lime	...	...	13

Another cheap glass may be made by using salt cake as an alkali. The proportions are somewhat as follows:—

Sand	...	100	Lime	...	...	35
Salt cake	...	60	Charcoal	...	...	5

This formula is very similar to the one suggested below for window glass, only in the latter formula all the materials must be fairly pure and free from iron.

For purposes of comparison the following series of formulæ will prove useful. These are for what is technically known as semi-white glass, substantially free from iron.

SEMI-WHITE GLASS.

Analyses of semi-white glass.

Sand	...	100	100	100	100
Alkali (S.C.)	...	26.5	S.S. 36	S.C. 32	(S.S.) 20 (S.C.) 14
Lime	...	25	24	20	20
Charcoal	...	Nil.	2.3	Nil.	11.2
Clay	...	3	Nil.	Nil.	Nil.

The first formula corresponds with that given by Thorpe (Dictionary of Chemistry).

It will be observed that the alkali content of semi-white glass is much greater than that for bottle glass. Clay which raises the melting point is generally absent in semi-white glass, because there is no iron present to act as a flux. In special glass, such as combustion tubing, clay again appears for the specific purpose of raising the melting point.

Window Glass.

The following formula is useful for window glass:—

Sand ...	100	Lime ...	35
Alkali (S.S.) ...	50	Charcoal ...	4

A glass that melts at a very low temperature and is easy to work but is liable to devitrify consists of the following:—

Sand ...	100	Lime ...	62
Alkali (S.C.) ...	52	Charcoal ...	2
(S.S.) ...	48		

Arsenic is sometimes included in this mixture up to 12 parts. In cheap glassware there is no necessity for employing it.

Another glass which is suitable for ordinary chemical laboratory ware but requires a fairly high temperature to melt consists of the following:—

Sand ...	100	Lime ...	17.5
Alkali (S.C.) ...	51	Clay ...	9.5
(S.S.) ...	Nil.	Charcoal ...	Nil.

The glass does not give up alkali readily to water, works well in the blow-pipe and does not devitrify.

The above formula is improved by reducing the proportion of alkali and increasing that of clay. The melting point is thereby very greatly raised and to counteract this, borax has to be added. We therefore obtain the following modification in the above formula, which gives a soft glass of higher quality, which does not give up alkali and is very difficult to devitrify. This glass really belongs to a class superior to the semi-white.

Sand ...	100	Clay ...	12.5
Alkali (S.C.) ...	43	Charcoal ...	Nil.
(S.S.) ...	Nil.	Boric anhydride ...	3
Lime ...	14.5	Calcium fluoride ...	2.5

SUPERIOR GLASS.

We now come to special glasses for special purposes. Of these, the most interesting is perhaps lampware. What is required in lamp chimneys is ability to withstand rapid changes of temperature. The glass represented by the appended formulæ possesses this property in an exceptional degree, but as will be evident from the formulæ, the glass is somewhat expensive to prepare.

The following formulæ are more or less the same, the second having been varied in order to avoid the use of the metallic oxides and to reduce the quantity of boric anhydride as this is an expensive salt:—

I		II	
Sand ...	100	Sand ...	100
Alkali (S.C.) ...	21.5	Alkali ...	Nil.
(S.S.) ...	Nil.	Lime ...	1
Lime ...	1	Clay ...	1.5
Clay ...	1.5	Potassium nitrate ...	4.5
Potassium nitrate ...	4.5	Boric anhydride ...	8.5
Boric anhydride ...	37	Anhydrous borax ...	40
Arsenious oxide ...	3		
Antimony oxide ...	1.5		

For high class ampoules and pharmaceutical purposes where a high-grade glass is required, the following formula can be recommended:—

Sand ...	100	Potassium nitrate ...	1.5
Alkali (S.C.) ...	25	Boric anhydride ...	12
Lime ...	18.5	Magnesia ...	0.75
Clay ...	15		

This glass is intermediate in hardness between soft glass and combustion tubing, is highly resistant to chemical action, withstands changes of temperature well and should be a very suitable glass for high-class beakers, flasks, etc.

An alternative is as follows:—

Sand ...	100	Borax anhydrous ...	20
Alkali (S.C.) ...	15.5	Zinc oxide ...	12
(S.S.) ...	Nil.	Magnesia ...	7.5
Clay ...	4		

A glass almost identical in its general behaviour with Jena resistance glass. It darkens and tends to devitrify. Operations—such, for instance, as sealing side tubing into flasks—are difficult, if permanent and neat joints are required. Unless special properties are required, the previous formula is to be preferred.

For combustion tubing the following has been suggested:—

Sand ...	100	Clay ...	9
Alkali (S.C.) ...	8	Potassium nitrate ...	6
Barium carbonate ...	13	Boric anhydride ...	8
Lime ...	19	Calcium fluoride ...	1.5

The glass resembles Jena combustion tubing very closely indeed. The presence of the small quantity of calcium fluoride facilitates the incorporation of the ingredients. The sodium carbonate can be reduced to 1.34 parts provided 7.93 parts of anhydrous borax are used in the place of boric anhydride.

A variant is as follows:—

Sand ...	100	Lime ...	21
Alkali (S.C.) ...	5	Potassium nitrate ...	6
Barium carbonate ...	13	Boric anhydride ...	8
Clay ...	9		

The glass is practically of the same composition as the previous one. It is not so easy to make or to work, but it does not become so opaque as Jena combustion tubing on prolonged heating. As before, the proportions of sodium carbonate may be reduced if anhydrous borax is used.

A third formula is as follows:—

Sand	100	Potassium nitrate...	4
Alkali (S.C.)	17	Borax anhydrous ...	10
Lime	Nil.	Magnesia	1
Clay	14		

The glass is capable of withstanding high temperatures and rapid changes of temperature. By slight modifications of the formula, almost any degree of hardness can be obtained. Magnesium and zinc can be added in the form of carbonates if the actual percentages of magnesium oxide and zinc oxide respectively present in the carbonate are known.

A soft soda glass suitable for tubing and X-ray bulbs is as follows:—

I				II			
Sand	100	Sand	100	Sand	100		
Alkali (S.C.)	3	Alkali (S.C.)	37	Alkali (S.C.)	37		
(S.S.)	Nil.	(S.S.)	Nil.	(S.S.)	Nil.		
Lime	19	Lime	19	Lime	19		
Clay	6	Clay	6	Clay	6		
Potassium nitrate	21	Potassium carbonate.	15	Potassium carbonate.	15		

These glasses do not lose their easy-working qualities after repeated heating and blowing and are plastic over a long range of temperature. They require a temperature of at least $1,400^{\circ}$ to $1,500^{\circ}$ C. for complete incorporation of the ingredients in order to obtain that homogeneity which is necessary for resistance to rapid changes of temperature and ease of working before the blow-pipe. The one containing potassium nitrate is considered the better of the two and is more easily incorporated.

Glass-making.

In 1908 a private glass factory was opened in Madras and the Government helped the concern by undertaking to supply free of cost half the quantity of fuel consumed in the furnace during the first two years of its working. The factory, however, did not work successfully and was closed down in 1911.

When the war broke out, the Director of Industries entered into negotiations with the present owner of the factory at Madras to carry on experiments with the manufacture of glass. On his recommendation the Government issued orders in G.O.

(R) No. 293 W., dated the 21st Feb 1916 to acquire the glass works. There is no information with Government as to whether the property has actually been acquired and handed over to the Director.

In a letter dated the 18th January last, the Director stated that he had constructed a new type of furnace and that he proposed to make trials to find out whether his organization was complete to undertake large scale experiments. It is not known how far he has progressed with these experiments. He has stated in another connection that

4. M. 677 Rev (J)
2.3.10.

⊕ Acquired - Page 7816
Fly. S.

para 12. page 7+8
of G.O. No. 225-ES-1
29.2.16 (I)

So affleg Q
* At the disposal of
in office. Removed

15

23

that he is addressing the Government separately in the matter. In this connection attention is solicited to a note written by Sir F. Nicholson in December 1914 regarding the feasibility of undertaking glass industry in this Presidency.

In a note forwarded by Mr. Tressler on 21st November 1915 he stated that the expenditure up to that date on the glass experiment was about Rs.8,000.

SK 27.5.16

HE

I propose to add this note and the file notes to the Comptroller for perusal

1. To.

2. The separate communication referred to at the top of this page should be asked for - from Mr. Tressler.

P 29.5.16

Comptroller 29/5/16

pages 2 to 8 of p. N. 7658
(not in file)

* Written in connection with the Legi. Council results re industrial experiments.

Box No 13
27-5-16

Extract taken for separate action
29/5/16
30-5-16

Department.

Office - Madras

In 1908 a private glass factory was opened in Madras and the Government helped the concern by undertaking to supply free of cost half the quantity of fuel consumed in the furnace during the first two years of its working. The factory, however, did not work success fully and was closed down in 1911.

When the war broke out, the Director of Industries entered into negotiations with the present owner of the factory at Madras to carry on experiments with the manufacture of glass. On his recommendation the Government issued orders in 1914.

There is no information with Government as to whether the property has actually been acquired and handed over to the Director.

In a letter dated the 28th January last the Director stated that he had constructed a new type of furnace and that he proposed to make trials to find out whether his construction was suitable to undertake large scale experiments. It is not known how far he has progressed with these experiments. He has stated in another communication that

Seen & returned.

I should be glad if I could have copies of Sir F. N.'s two notes (glass & pencils) to keep with me.

The file contains no information regarding the cause of the failure of the glass company. I shall make early enquiries into this before submitting any remarks on the scheme.

I remember reading, in the printed papers regarding the Industrial Conference of 1908, some remarks of Mr Chatterton in which he pointed out that though the imports of glass are large, they are made up of many different classes of goods, each of which require separate plant to produce, so that any one factory could only produce ^{only} a small part of the imported glass. He also alluded to the chimney difficulty. In conversation with me lately Sir F. N. said that if suitable sand could be found (which he doubted) the best prospect of success lay in bringing

Copies of Sir F. N.'s notes are being sent separately.
31.5.16

the raw materials up to the
 higher, where there was cheap fuel
 & where the climate would be
 more favourable.
 I shall consider these points
 when submitting my report.

Since Feb
 1915 3-8 CF.

Boe No 19
 1.6.16

31 MAY 1915

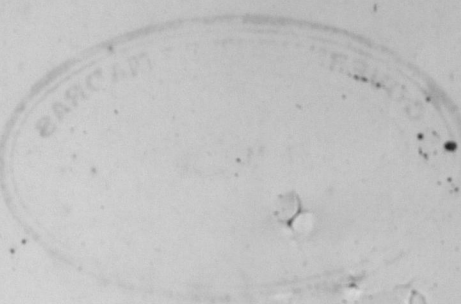
GOVERNMENT OF MADRAS

31.5.16

2.6.16

The report completed
 by Mr. Porter may be
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31/5/16



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GOVERNMENT OF MADRAS

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31/5/16

p. 2 of cf.

p. 9 of cf.

page 2 to 13 of cf.

page 8 of cf.

page 13 of cf.

CR-2824. From Mr. Bonchman N.E. 8 of 27.6.16.
 CR-2859. From the D.S. N.E. 8 of 31.7.16.

Mr. Bonchman & Mr. Treacher both submit their reports on the glass experiment now carried on in the Industries department. The reports show that the experiment ^{is encouraging and affords promise of success} ~~has to be successful~~. In order to further continue it Mr. Bonchman requests

- (1) that one Mr. Klein may be employed temporarily on Rs 200 per mensem
- (2) that permission may be granted to the Director to make enquiries for a glass expert in England.

Besides, Mr. Treacher requests that sanction may be accorded for incurring an expenditure of Rs 1000 per mensem for a period of six months on the experiment in addition to the pay of the expert.

2. Employment of Mr. Klein.

From Mr. Bonchman's letter it is observed that Mr. Klein will

page 6 of cf.

In the file proposing the appointment of Karayamamur as an agricultural engineer. The file has been sent to Revenue.

Please see page 3 of Badshah No. 25 attached hereto.

page 6 of cf.

Pr. No. 13 Rev. of 4.1.16 (F)

page 17 of Pr. No. 777 Rev. of 4.1.16 (W)

Pr. No. 193 Rev. of 11.1.16 (G)

be engaged in training workmen and in carrying on the experiment generally. In another connection it was brought to the notice of the Govt that Mr. Karayamamur, the senior supervisor of the dept. was working in this business and that he would continue in it for another six or nine months. Apparently, he cannot be entrusted with the work for which it is proposed to employ Mr. Klein. Mr. Benckman says that the latter has spent many years in glass works in France. It is therefore for orders whether his employment may be sanctioned temporarily.

It may be noted here that at the beginning of this year Mr. Klein was employed temporarily for carrying on certain boiling experiments. But as these were subsequently abandoned his services were dispensed with very soon. Being a European the sanction of the Govt of India was obtained for his employment.

ment under Art. 773(a) of the Civil Account Code, Vol II. It does not appear that this sanction will cover his reemployment now in the glass experiment & it may be necessary to address the Govt of India again in the matter. ^{remarks of the Govt. may be wanted (no)}
3. Enquiry for a glass expert in England.

page 6 of cf.

page 8 of cf.

Mr. Bonchman says that if Mr. Klein proves good enough there may be no need to get another expert from England. Further he assures that no expert will be employed without the sanction of the Govt. It is submitted that the engagement of persons in the United Kingdom for service in India rests with the Secretary of State & it may therefore be necessary to address him through the Govt of India in case an expert should be recruited. But there seems to be no objection to the Director making enquiries if the services of any expert will be available.

page 13 of c.f.

In six months at Rs 1000.

In six months at Rs 200.

Please see tabular statement at the bottom of page 7 of c.f.

4. Expenditure of Rs 1000 per month on the experiment.

The Director recommends that in order to undertake ^{trials on a} large scale a sum of Rs 1000 should be spent each month for a period of six months. Mr. Bonchman has not expressed any opinion on this matter. If an expert like Mr. Klein is employed it will be necessary to provide the necessary funds ~~for him~~ so that he may bring the experiment to a successful completion. It may not be difficult to meet the sum of Rs 600 required for the experiment together with the sum of Rs 1200 required for the pay of the expert from the provision of Rs 3700 available for miscellaneous experiment. ^{It is for consideration whether} Mr. Bonchman ^{should now} ~~may~~ however, be formally consulted on this matter. ^{It is considered unnecessary} If the proposal to employ Mr. Klein ^{may be} accepted ^{and formal orders issued} ~~after obtaining the views of~~ he made before the file is sent to the Financial Dept.

20/11/16
7.8.16.

Submitted that Mr. Conchuan's proposal on page 8 of ^{the} (i) to employ Mr. Klein on Rs. 200 per month first for a period of six months & (ii) to institute enquiries about an expert. Mr. Conchuan does not specify the period for which Mr. Klein should be engaged, but from Mr. Trevelyan's letter it seems that the experiment should first be conducted for six months, Mr. Klein's suggestion may also be for that period.

The sanction obtained for Mr. Klein's appointment in connection with the ^{abandoned} honing experiment in the Dini island cannot apparently be used for the present purpose. That sanction was for $\frac{1}{2}$ six months and was ^{also} utilized to the extent of one month & a half (Mr. Klein joined the appointment on the 15th January 1916 & was released on 1.3.16). Fresh sanction for his employment on glass experiments is therefore necessary.

The funds requisite for the experiments are available in the Industries Budget.

As it is likely that the new furnace would be ready by now, sanction may be accorded to Mr. Klein's appointment ^{as an} urgent measure & fact reported to India.

CA
21.3.16

1917 of 77750 (W) 21/4/16

(W) 21/4/16

Box 44
Circ. 22/8/16
Retd. 24/8/16

NOTES.

Page

HE Please see
Couchman's report - pages
36 & 37. It is decidedly
encouraging. Mr. Klein
apparently may be
Sanche's attorney for
a period of six months.
and India addressed
for ratification of our
action. The file may
then go to Mr. Couchman
to see what
funds he will
need for the experiment.
Mr. Torber mentions \$1000
per. for a period of
six months; but Mr.
Couchman says nothing
about it.

Page 13 CF.

22/8/16

P
2A. 6. 16.

SECRETARY TO GOVERNMENT
OFFICE
JUL 15 1911
OFFICIAL DEPARTMENT

A draft order & a draft letter
are submitted for approval.
It may be sent to the Financial
Dept. for acceptance. The question
of funds for the experiment
will be taken up afterward
and file referred to Mr. Couchman
as directed on p. 10 above

28. 8. 76

Dr. H. W. 29.8.16

To the present case. Financial Dept.

For the Ash. See.

3 Provision of funds in connection with

The proposals of the Home (Est.)

Dept. is ~~to~~ to sanction the employment

to Mr. H. in a box of Rs 200 per box

— 1000 —

a period of six months for conducting

Experiments in glass-making. The propos

ASSISTANT SECRETARY
GOVT. OF MADRAS

* as it is proposed to meet the charge from the high apartment for misc. industrial experiments.

A circular ink stamp from the Chief Secretariat of the Madras Government. The outer ring of the stamp contains the text "CHIEF SECRETARIAT" at the top and "MADRAS GOVT" at the bottom. In the center of the stamp, the date "30 AUG 1946" is stamped.

Σολος 1963-7

CLASIFIC. NO.
4944
SERIAL

Regd 20846

(draft order)

The proposals of the Home (Edl.) Dept. is ~~to~~ to sanction the employment of Mr. Klein on a pay of Rs 200 pm. for a period of six months for conducting experiments in glass-making. The propos

p. 10 ante

has been approved by His Excellency. In the circumstances stated by Mr. Couchman on pages 3-8 CF., the proposal may, it is submitted, be ~~also~~ accepted in Financial. It is however pointed out that the case should have been sent to Financial before submission to H.E. on 22.8.16 - vide Rule 14(a) of the Council Rules.

page 9 ante
+ draft letter

2. The view of the Home (Edl) Dept. that fresh sanction of the Govt. of India ^(is necessary) under art. 773(a) of the C.A. Code. Vol. II for the present employment of Mr. Klein seems correct. Home Dept. letter No. 2478 & 12-12-98 recorded in S.O. No. 2. Pub. & 2-1-99, in which Govt of India have stated that when once their sanction has been obtained under art. 773(a) of the C.A. Code, future promotions in the same dept. would go in the ordinary course without further reference, is not applicable to the present case.

(in rel. part of)
DA

3. Provision of funds in connection with

the appointment of Mr. Klein - Submitted that the Home (Edl) Dept. may be requested to insert a sentence in the draft order to the effect that the cost on account of the appointment will be met from the allotment sanctioned for expenditure.

I agree. The cannot. Sanction the app't. & then look round to see where the money can be got from. The money must be provided first. DA

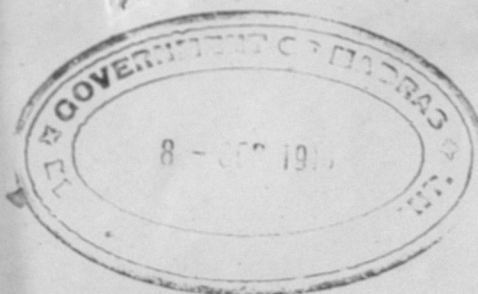
in 1916-17 on miscellaneous experiments.

4. The Home (Edl) Dept. propose to settle later on in consultation with Mr. Couchman the amount to be sanctioned for the conduct of the glass making experiments. Pending the formulation of definite proposals on the point, no remarks seem called for in financial.

5. The draft order and letter may, it is submitted, be accepted, subject to the remarks in para 3 above.

A criticism that occurs to me is that it is proposed to appoint Mr. Klein till Home have decided what money should be spent on experiments. Mr. Klein is being appointed to carry out the experiments. Home dept. will no doubt consider this aspect of the case, and so far as Mr. Klein's appointment goes it may accept the proposal. He will have to be appointed sooner or later.

Notes in A-4
8-9-16



File no. 4944-1
7-9-16

LD. 7-9-16
7/9 Home (Edl) no

CS. 5-9-16

27/14
D.O. from M.E. Couchman, Esquire, I.C.S., dated
the 9th September 1916:-

x

x

x

I should be glad if you would obtain early orders
on my proposal to try to find a glass expert at home. The
time is getting short.

Please take this extract and place it on the other
file re: the glass expert and let me see that other file at
once.

P.R.
11-9-16.

Home (Est.) Dept.

With reference to para 3 of
 Int. note ^{on page 12 ante} the following
 sentence may be added to the
 draft order after the first para:-

"The ~~extra charge~~ ^{cost} ~~on account~~
 "of the appointment will be met
 "from the provision made
 "in the current year's budget
 "estimate for 'miscellaneous
 "experiments' under the head.
 "26-Bw-Scientific re., Dept.-
 "Miscellaneous."

2. With reference to the Asst.
 Secretary's note on ~~the previous~~
 page ^{13 ante} a separate no. note to
 Mr. Conchman is submitted from
 below. A para has been added to
 the no. note with reference to the
 extract from Mr. Conchman's do. on
 the previous page.

⊗ Sent to Mr. Conchman
 separately.

SA
 11.9.16.
 11/19/16

SA
 11.9.16
 Le

17.9.16

[Sp. No. 962 of the 12.9.16]

READ ALSO:—

" " 28 59 " " Director of Industries, " the 31st July 1916

191

No. 962, dated 12.9.1916

mis

The cost will be met from the provision made in the current year's budget estimate for 'miscellaneous experiments' under the head 'Ab. B. n. Scientific & Dep. - Miscellaneous'.

The Government sanction the employment of Mr. Albert Klein on a pay of Rs. 300 per mensem for a period of six months for conducting experiments in glass-making.

3. Mr. Klein's appointment will be reported to the Government of India for confirmation.

S.K.
38-8-16.

N.K.
28-8-16.

C.R.
28-8-16.

M. E. Couchman, Esq., I. C. S.,
Officer on Spl. Duty,
Dept. of Industries.

The Accountant General.

LETTER:- *Nº 9638 12. 9. 16.*

To

The Secy. to the Govt. of India,
Home Department.

Sir,

I am directed to address the C

of India on the subject of the employment of Mr. Albert Klein to assist in making some experiments in glass-making in this Presidency.

2. In 1909 a company was formed in Madras for the manufacture of glass and it set up a factory with the necessary plant. Owing to various causes the factory did not work successfully and was closed in 1911. The plant and buildings were recently acquired by this Government, at a cost of Rs. 33,000, and the local Director of Industries has been making a series of experiments in glass-making in the factory. The results of the experiments are so far encouraging. With a view to train the necessary workmen the Director has recommended the employment, as a temporary measure, of Mr. Albert Klein who has acquired experience in glass works in France. As the new and improved furnace to be used in the manufacture has been completed and Mr. Klein is urgently needed, this Govt. have sanctioned the employment of Mr. Klein for a period of six months on a salary of Rs. 200 per mensem. I am to request that the Government of India will be pleased to confirm the action of this Government under article 773(a) of the Civil Account Code, Volume II.

3. In this connection I am to refer to the correspondence ending with Mr. Hignell's letter No. 186-C, dated the 23rd January 1916, according sanction to the employment of Mr. Klein in the conduct of

boring experiments in the Divi Island which have however been since abandoned.

N.K.
28-8-16.

C.R.
28-8-16.

Sp. No. 677 Rev (J)
2-3-16

pages 3 & 4 of cf.

Sp. No. 293 W (R)
21-2-16

page 6 of cf.

page 1 of Sp. No. 193 Rev (G)
21-1-16

29-8-16

When given for copying _____
 When copied _____
 When examined _____
 When signed _____

191

READ AGAIN G.O. No. _____
 191 .

. DATED

CURRENT No.

ENCLOSURES TO C. No.

ORDER OF GOVERNMENT.

A A A A A A A

LETTER OF GOVERNMENT.

LET WITH DETTO.

PAPERS NOT FILED UP, BEING MEANT FOR DESPATCH
 IN ORIGINAL.

V.E.-

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