FACTORS IN TEA MANUFACTURE.

D. I. EVANS.

The process of black tea manufacture may appear to a casual observer as carried out to a great extent by rule of thumb, and a closer study of factory methods will divulge that, although details may vary, the general principles remain the same. The leaf is withered, rolled, fermented and fired in very much the same way on all estates, and yet the quality of the product varies in a manner which is not easy to explain. This difference in quality is due to a variety of factors, which must be borne in mind when considering any individual case. It would take us too long to discuss all the factors this morning and I should like just to mention some of these while dealing more fully with one or two which are of particular interest.

The first necessity for successful tea manufacture is sufficient space and machinery to deal with the crop produced in the heavy yielding months, an economical and rational lay out of the factory, and a staff of operatives as mechanically perfect in the routine of the factory as is possible. In spite of this there will still be differences in the quality of the product, and some of this difference must be attributed to the crop. This will vary with the jât of the bush, type of soil on which it grows, elevation, aspect, and climatic condition. Very little is known concerning the precise effect of these factors on the quality, except in general terms. Thus it is probable that elevation does affect the quality of the crop; but it is not clear whether this effect is due to altitude at such or because of the resulting temperature changes.

Apart from these more or less permanent factors tea is subject to seasonal variations produced by the change of weather, pruning, shade, and style of plucking adopted.

Another important factor in tea manufacture is the variation in crop produced. The yield may increase rapidly at certain periods of the year so that, unless this is taken into account when constructing the factory, the withering space may not be sufficient to deal properly with the crop at the rush period. There may be a shortage of machinery at the same time, and the quality of the crop will suffer. The crop at this heavy yielding period may not be so good in quality as the normal leaf, but the crop is so heavy that care taken to produce the best at this period is well repaid if only slight improvements are effected. The heaviest yielding periods should thus decide the size of the factory required.

This increase in the crop at certain periods involves more work per day in tea making. It is further complicated, however, by the fact that the rush months generally correspond with wet periods, and

not only is the weight of crop greater, but the work done per pound of tea turned out is also greater. This is very evident when the moisture relations during manufacture are considered.

	Total weight of water evaporated Lb.	Wt. of water lost per lb. of tea.
February ...	27,447 ...	2·77
May ...	40,308 ...	3·38

This loss of moisture is obtained in two different steps during the manufacture:—

(1) During withering
(2) During firing.

Much of the water associated with the leaf is due to surface moisture, and represents a weight of substance which has no real connection with the leaf. This means that this weight of water must be driven off before proper withering starts, and, in calculating the wither, the weight of withered leaf must be either referred to a smaller weight than that of the wet fresh leaf, or else the wither must be harder than is the case in the dry weather. The unevenness produced by wet leaf should thus be evened off during withering, so that the leaf taken for rolling contains very nearly the same amount of moisture every day. In this way uniform material is obtained for rolling, fermenting and drying, so that a good criterion of withering is the out-turn of fired tea on withered leaf. The greater moisture per pound of made tea thus involves more work on the leaf during withering. The range of variation in the moisture of the leaf coming into the factory is very high, the limits determined last year being 2·50 lb. and 4·60 lb. of water per pound of dry tea. It is, therefore, necessary at times to drive off as much water, or more, from the leaf in withering as would be evaporated during the whole process of tea making at other times.

Unfortunately the greater work involved in withering at this period has to be done under less favourable atmospheric conditions. It thus becomes necessary to prolong the wither, or else to take the leaf for rolling before it is properly withered. It is not always possible to keep the leaf in the factory until a proper wither is obtained, and it is not advisable to roll unwithered leaf, so that artificial methods have to be resorted to. Artificial methods of withering utilise slightly heated air in order to obtain a drier air, and this leads us to the consideration of the effect of heat on the leaf during manufacture.

When green leaf is steamed it loses its power to ferment and produce a coppery colour. Temperatures above 90°F cause the plucked shoot to turn red, the rate at which this reddening takes place

being dependent on the temperature. According to experiments carried out by the Scientific Department of the Indian Tea Association, leaf reddened in 3½ hours at 115°F, and in 10 minutes at 138°F. This change must take place at lower temperatures but at slower rates. It is, however, easy to wither fresh leaf under Ceylon temperature conditions without any trace of red appearing, but certain conditions during plucking and transport tend to produce reddening unless this is carefully guarded against. Fresh leaf will not wither green in strong sunshine, but it becomes coloured in a very short time, so that undue exposure of plucked leaf to strong sunshine makes for red leaf. When the leaf is taken off the bush it is still living and respiring. This means production of heat energy in the mass of leaf in the plucking baskets. If this heat is not allowed to escape, high temperatures will be developed in the baskets and red leaf will result. According to the Indian investigators temperatures up to 140°F may be experienced in the middle of a plucking basket. I have not seen such high temperatures, but the leaf coming into the factory is invariably at a higher temperature than the atmosphere. With every precaution I have seen the leaf coming in recording 86°F, so that carelessly packed leaf can be at a much higher temperature than this. Actual reddening may not be visible, but nevertheless changes which make for red leaf and loss of quality will take place as a result of this heating. Great care should be taken in transporting the leaf into the factory at frequent intervals during the day, and it should be spread out as quickly as possible and not left lying about in heaps or in bags. The same strictures apply to the application of heat during withering, only that lower temperatures may have greater effects on the leaf because of the longer period it is allowed to act, and because the effect of heat is more pronounced on withered leaf than on fresh leaf. It is, therefore, advisable to maintain as cool conditions as possible during withering, and use discretion with the use of warm air. At lower elevations where temperatures are higher greater care still should be taken. The higher atmospheric temperatures, however, mean a greater efficiency in the drying capacity of the air, so that air conditioning by adding warm air need not be so drastic at lower elevations. Not only does temperature affect the leaf during transport and withering, but it is also an important factor during rolling and fermenting. According to Nanninga, who carried out experiments on fermentation many years, ago, fermentation should be carried out at 77°F, and H. H. Mann pointed out that a normal fermentation is obtained up to 82°F, but that when this temperature is exceeded a second reaction sets in, which results in the production of insoluble dark-brown products, followed by a loss of pungency, colour and body in the liquors. He also pointed out that temperatures up to 86°F have little effect on the production of aroma during

fermentation. Both of these investigators then agree that temperatures above 85-86°F are detrimental. More recent work carried out by Deuss in Java indicated a range between 68°F and 77°F as being the best for fermentation, and some factories in Java have described how they maintain their fermenting room temperature within this range.

These temperature conditions have been determined for leaf put out to ferment, but there is very little reference, if any, to the temperature conditions during the rolling process. It is now realised that fermentation takes place during rolling, in fact some of the leaf may complete its fermentation in the rollers. It is therefore necessary to consider the temperature conditions in the rollers, When this is done it will be found that fermentation is proceeding at high temperatures, very often well above the maximum allowed by Nanninga, Mann and Deuss. The rolling process should thus be watched very carefully if high temperature fermentation is to be avoided. Fortunately at high elevations the rolling room temperatures are low, so that a rise of temperature in the rollers can take place without exceeding the safety limit, but with higher rolling room temperatures it must be very difficult to keep the temperature of the leaf down below 86°F.

I am not propounding any new theory by saying that heat is developed in the rollers; you are all aware of that and the tendency to shorten the rolls, and to pay particular attention to the manipulation of the pressure cap, is due to the fact that experience has taught you it is necessary to avoid high temperatures in the rollers. I am not so sure, though, that it is realised that the heat produced is due to

(1) Friction in rolling the leaf.

(2) Heat generated as a result of fermentation of the leaf, and which would still be developed if there was not churning of the leaf in the rollers. This increase in temperature may be as much as 20-25°F even with careful rolling, but a casual observation of the leaf may give very little indication of this heating. Sometimes with careless rolling the leaf coming from the roller may be sensibly hot, and this is bad, but on the other hand the leaf may seem to be only just warm to the touch. Such leaf very often registers a temperature of 83-87°F. When the temperature of the rolling room is higher than this the roller temperatures are liable to be over 90°F which is well beyond the limit advocated. A certain amount of heating in the rollers does not always mean bad results, however; under certain conditions it improves the appearance of the infusion, but high temperatures as such are undoubtedly detrimental.

How is high temperature to be avoided? This can be done by a careful regulation of the pressure and the period of applying it. The effect of hard and light pressure on the temperature of the leaf coming from the rollers can be seen from the following figures:—

Temperature increase of rolled leaf under different rolling conditions.

Roll.	Heavy Pressure	Light Pressure.
1	21°F	10°F
2	21°F	13°F
3	22°F	14·1°F
4	19°F	16°F
5	16°F	18°F

Control of the presure applied will thus regulate the heat developed to a certain extent, and I understand that an attempt has been made recently to control the temperature of the leaf in the rollers by fitting cooling jackets to the rollers, but I have no information as to the degree of success obtained as a result of this. A cool rolling room of course is a first essential to cool rolling, and this can be obtained by means of humidification, which will be referred to later. Rapid cooling of the leaf coming from the rollers can be obtained by spreading the leaf mass immediately it comes from the rollers. Perhaps the effect of roll-breaking in cooling the leaf is not quite realised, but some idea of this can be obtained from the following data:—

	°F.
Temperature of the leaf coming from the rollers ...	84
,, ,, ,, ,, ,, at beginning of roll-breaking	74
,, ,, ,, ,, ,, at end of roll-breaking ...	70
,, ,, ,, atmosphere	70

Leaf cooled in this way will thus start the next rolling period in as cool a condition as possible.

High temperatures are therefore bad for fermentation, but there is a certain amount of evidence that fermentation is difficult and uneven at low temperatures, though the limit of 68°F set by Deuss appears to be too high. Excellent results are obtained at lower temperatures than this, but the practice of returning the dhools to the roller shows that low temperatures are troublesome at times, and a warmer ferment is obtained by returning the dhools to the roller. The average temperature of fermentation of the separated dhools at St. Coombs is below 68°F, but this does not prove that better results would not be obtained between 68° and 77°F. The leaf which ferments in the rollers is doing this at a temperature varying between 75° and 86°F. Sometimes during the dry periods of the year the temperature of the leaf fermenting on the floor may be below 68°F, while the leaf in the rollers is fermenting at 75-80°F. It will thus be seen that in actual practice it is very difficult to say what is the temperature of fermentation. There is, then, a danger of too

cold a fermentation and the ideal conditions for rolling becomes detrimental for fermentation of the leaf removed from the rollers. This condition is not likely to arise at low elevations, but it is quite possible at high elevations where the rolling room temperatures may be very low. A cool temperature is required for rolling, but if the leaf separated is fermented in the same room the temperature may be too low for its fermentation. This raises the question "is the policy of fermenting in the rolling room a safe one"? The evidence seems to be against it, and it would appear to be better to have a separate fermenting room in which the temperature and humidity could be controlled to any desired extent.

Nanninga who was the first to investigate low temperature fermentation found the development of colour to be very slow, and that the aroma was much less pronounced at 57°F. It is possible, however, that temperature conditions affect the different reactions, which proceed during fermentation in different ways so that low temperature conditions may be beneficial for some and not for others.

Successful fermentation depends on the proper adjustment of the conditions so that most is made of all the reactions, and this cannot be attained until more is known concerning the reactions which take place.

The question of temperature of fermentation is closely connected with that of humidity. Bamber, Mann and others had pointed out that it was necessary to maintain a humid atmosphere in contact with the fermenting leaf, and Deuss found fermentation in a dry atmosphere resulted in uneven fermentation, and produced irregular infusions and dull liquors. The effect of a dry atmosphere is not corrected by turning over the leaf, since this practice only makes new surfaces for drying. Fermentation according to these investigators should be carried out in an atmosphere of 90-95% relative humidity, and cold dry draughts should not be allowed to play on the fermenting leaf. This is in agreement with practical experience, but observations made on the performance of a humidifying plant show that proper humidification means more than this. Fermenting leaf requires oxygen for the process so that the room in which fermentation is carried out should be well ventilated. It is possible to combine humidity with aeration and this is ensured in a plant such as exists on St. Coombs, where the volume of humid air supplied is sufficient to change the air of the rolling and fermenting room every 4-5 minutes. This ensures an ample supply of fresh air for the fermenting leaf and for the operatives.

The wet bulb temperature of the atmosphere is very low during the dry periods of the year, so that if humidification of the air can be obtained without increasing the wet bulb temperature in the process,

a cool room is ensured and this helps the rolling process considerably. A further advantage is also obtained because the rapid increase in temperature which takes place outside during the day is not experienced in a properly humidified rolling room, *i.e.*, a more uniform temperature is obtained throughout the day. This effect can be very well seen from the accompanying table where the gap between the outside and rolling room temperature gives some idea of the cooling effected.

Cooling Effect of Humidification.

Rolling Room Temperature °F.			Outside Temperature °F.			Cooling
Dry	Wet	Difference	Dry	Wet	Difference	Effected °F.
69	67	2	80	67	13	11
59	56	3	75	57	16	16
59	56	3	73	57	16	14

A further advantage of humidification is that it allows of thinner spreading of the fermenting leaf, which may be left to develop a full fermentation even during very dry periods. If no humidificatoin is resorted to the leaf dries up and blackens, and to avoid this it is spread thickly and very often taken to the dryers before it has had time to ferment properly.

Fermentation is initiated by the pressure exerted in the leaf during rolling, but it is more difficult to find out what actually happens in this process than in any other stage of manufacture. The obvious effect of rolling is that of cutting up the leaf which is of great importance for the later operation of grading. The shearing effect of rolling can be followed by weighing the dhools separated after each roll breaking. It is found that the greatest factor in the separation of dhools is the pressure applied in the rollers and the care given to roll breaking. An example of the difference in the separation of the dhools as a result of heavy and light rolling is given in the table.

% Separation of Dhools.

Roll	Heavy Pressure.		Light Pressure.	
1. ...	32·0		13·0	
2. ...	23·2	69·7%	14·9	42·8%
3. ...	14·5		14·9	
4. ...	10·5		19·7	
5. ...	14·5		25·0	
B Bulk ...	5·3		12·5	

Although higher temperatures are obtained with heavy pressure than with light pressure, this is neutralised to a certain extent by the

removal of a greater portion of the leaf from the seat of high temperature to the cooler conditions of the fermenting room. In this way, 69·7% of the leaf being manufactured is fermenting in cool conditions after 3 rolls, as a result of heavy pressure, whereas only 42·8 per cent has been taken from the high temperature region in the same period with light rolling. The nett result of light rolling is thus a cooler maximum but a longer fermentation at the moderately high temperature. Temperature of fermentation in the roller can thus be controlled by means of the pressure applied to the leaf, but it must be borne in mind that a change in the pressure also means a change in the rate at which the leaf is fractionated out.

Under experimental conditions the shearing effect of the rolling can be examined more closely by actually sifting out the various sized particles in the rolled leaf at different periods during rolling, and estimating the amount of tip and stalk which separate out under different conditions, and by this I mean an actual count or weighing of the tip and stalks. Thus, in the case of the light and heavy rolling experiment previously referred to, light rolling separated 14·2 per cent of tip in the first roll, whereas heavy rolling only gave 9·2 per cent. Again, where light rolling finished up with a big bulk of 24 per cent stalk, heavy rolling finished up with a big bulk of 44 per cent stalk. The process can be followed further by determining the grades turned out, the number of cuts required and the yield of dust and pickings obtained as a result of the different treatments.

It is not possible to make such a careful survey of the rolling process in practice, but it is a simple matter to keep all the dhools separately and to weigh them before they are sorted. This will supply a good check on the conduct of the rolling operatives. It will be found that there is some variation from day to day as a result of variation in the nature of the leaf coming in, but after a time it is possible to gauge what margin of variation can be allowed for the leaf and what is really due to neglect on the part of the cooly. There is another advantage in keeping a record of the dhools, because it can be referred back to years later, if necessary, to see whether there has been any alteration in the manner of rolling in the course of time. This can be very useful to a new-comer to an estate, since he can gauge at once the type of rolling carried out by his predecessors.

These are a few of the factors concerned in tea manufacture, there are many others which I have not touched upon, to do so would be to keep us here indefinitely. These remarks will show that there are many points to be decided upon yet, but I hope this will not create a pessimistic outlook, as many problems which remain unsolved should yield to experience and research. Time, however, is an essential condition to success, and it can only be after months of research that there can be a sufficient supply of scientific data to enable positive conclusions to be reached.

DISCUSSION.

Mr. W. S. Burnett, before proceeding to a discussion of the paper, said that he felt he was voicing the sentiments of all those present by expressing his appreciation of the very valuable paper read by Dr. Evans. He said that he, personally, thought that manufacture was more important than pruning, because it was possible that in the next few months their very livelihood would depend on the quality of the tea that they turned out. Mr. Burnett then read the following extract from a circular received from his Agents—"It is earnestly hoped by all traders that producers realise that the only possible solution of the difficulty is to concentrate all efforts on the production of the very finest tea which their estates are capable of. To effect this, attention should be devoted to fine plucking and the most careful manufacture—quality will quickly bring its own reward as proved by certain gardens and districts during the past season."

Mr. J. E. B. Baillie-Hamilton asked whether light played any part or not in fermentation and **Dr. Evans** replied that nothing has been done on this problem since Mann investigated it some years ago. Mann concluded that provided glare was avoided, then light had no effect on fermentation. This was a point which was being kept in mind and which would be inevstigated at St. Coombs.

Mr. Orloff Coombe asked why the fermentation of indifferent jâts of leaf appeared to be more rapid than that of good jâts.

Dr. Evans mentioned that he had already stated in the beginning of his paper that nothing was known concerning the effect of jât, climate, etc., on quality. He pointed out that it had been impossible to investigate problems of this nature in the short period they had been at St. Coombs.

Mr. Bruce Foote, referring to the table giving the increase in temperature of the leaf in the rollers, asked why the temperature of the leaf in successive rolls under heavy pressure diminished, whereas under light rolling conditions this increase of temperature became more and more pronounced.

Dr. Evans agreed that the condition found appeared, at first sight, to be somewhat strange but the effect observed as a result of heavy rolling was due to the fact that strong fermentation was set going in a great mass of leaf in the *early* stages. The mass of the leaf remaining in the rollers was also greatly reduced with heavy rolling, so that the actual amount of fermenting leaf producing heat would be comparatively small in the last rolls and the ratio of surface to mass exposed to the cooling effect of the air would be sufficient to allow of keeping the leaf cool. With light rolling, on the other hand, the production of fermentation in the leaf must be a gradual one, increasing steadily as the pressure was increased. The mass of leaf, however, was not reduced so rapidly as with heavy rolling so that this resulted in an increased fermentation of a large quantity of leaf, which would not cool so rapidly on rolling as the comparatively small bulk left with heavy rolling.

Mr. Orloff Coombe pointed out that leaf was usually spread about one inch thick for fermenting, and it seemed to him that under such conditions the only leaf which came in contact with the atmosphere was that in the top layer. Why was it necessary for correct fermentation of tea to change the atmosphere every four or five minutes, was the action chemical or physical ? The speaker had carried out factory experiments himself on the question of aeration of the leaf during fermentation, but did not find any difference in the tea produced with leaf given plenty of oxygen from leaf which had been covered with a box so as to exclude entry of air.

Dr. Evans replied that a greater oxidation must occur at the surface than in the body of the fermenting leaf mass, but that with thin spreading a certain amount of air permeated into the leaf mass. He said that there

was a certain amount of misapprehension concerning the question of ventilation in the rolling and fermenting room. The necessity for a change of air every four or five minutes was due not so much for supplying fresh oxygen, but because of the heat developed in the rolling and fermenting room. Heat was generated in the rolling room by the fermenting leaf, the moving machinery, the operatives and by radiation from the walls. This heat developed was countered by blowing cold, humid air into the room, so that the volume of cold air admitted into the room must be sufficient to overcome this heating effect. This can only be obtained by a fairly rapid change of the air in the room.

Mr. H. C. Carmichael said that they heard much about perfect withers, perfect rolling and perfect fermentation, but he would like to know something about the end of manufacture—firing. He would like to know whether anything had been discovered as to the correct method of firing, and whether quality of flavour was lost up the chimney in the process of firing.

Dr. Evans replied that quality and flavour might be lost in the firing process, but the proper conditions of firing had not been determined. Some people preferred a high temperature and others persisted in maintaining as low a temperature as possible, but no investigations had been carried out by him on his point.

Mr. J. Horsfall said that Dr. Evans had suggested that certain figures be kept in the factory for reference, and he would like to suggest that any Superintendent who adopted this practice would have to be very careful of the teamaker who would soon know "what master liked to see." He, therefore, recommended planters to be careful to adopt their own particular systems of checking the correctness of these figures.

Mr. Horsfall, commenting further on the paper, stated that the figures relating to the percentage tip separated in light and heavy rolling did not necessarily show that heavy rolling resulted in loss of tip, since the percentage tip isolated in the ghool would be less on account of the greater bulk of leaf sifted out. Concluding, he stated that he wishesd to congratulate Dr. Evans on his excellent pamphlet entitled "A Handbook of Factory Information."

Dr. Norris announced that copies of this pamphlet would be available to members who desired to have them after the meeting.

Mr. E. C. Marsh Smith in a letter read by Dr. Evans said that it was very generally understood now amongst planters that faults in rolling, fermenting, firing, and sifting could easily be traced (or comparatively so) especially from brokers' remarks on samples. But when the faulty, or rather unsatisfactory manufacture, pointed to wither, it was difficult to know whether it was wither alone or wither combined with fermentation. Plenty of conditioned air, or a natural wither with open windows, had always been spoken of as being a basic condition of good wither, but, lately, owing to the success of certain factories in getting high prices, opinion seemed to be veering the other way, and slow natural withers, even if windows had to be kept shut, were preferred to quicker withers by the use of fans; however well-conditioned the air. He knew of one factory where, by slowing down the wither in dry weather and keeping out the damp winds during wet weather, prices had improved enormously. In two other factories where prices were always exceptionally good, the leaf was not even spread thinly and withers were allowed 36 and 48 hours. Did that mean that in the case of quick withers, physical wither was completed before the chemical, in that better prices were procured for the slow withered teas ? These teas were thicker and stronger in liquor. If one could leave the leaf to wither any length of time without artificial aids such as fans and get better results, he failed to see the object of the Commercial Co.'s system. Those factories where slow withers (often with windows shut)

were the practice got uniform and even withers because one end of the loft was not subject to a rapid stream of air, while the far end was under air practically stagnant by comparison, speeds often dropping 50 or 60 per cent. over the length of the loft. Did it all come to this? Slow hard withers gave a soft even leaf, easily broken up by rolling, while hard withers, by opening windows or by artificial means hardened the surface of the leaf and left the inside not withered or only partially so?

Personally, he got thin liquors every time a hard wither was attempted. If a longer ferment was tried to counteract this, then the infused leaf was inclined to be duller. He asked if pressure applied from the early rolls counteracted thinness of liquors. With hard withering he got a lot of buds blackened like fired tea and the dust grade increased.

Dr. Evans agreed that undoubted success was being obtained in certain parts of the country by means of very slow withers. He knew of instances where by adopting a policy of slow wither, or by extending the withering period by piling the leaf on the tat to prevent too quick a wither, a beneficial effect had been produced in the teas marketed. It was claimed that such a policy resulted in giving the tea a particular characteristic demanded by the market, whereas a quick wither resulted in a plain, uninteresting tea. Such success, however, depended to a certain extent on the possibility of having sufficient withering space for the leaf to be kept in the factory for the necessary length of time. If this could not be done and a wither was not obtained in 18-24 hours, it was necessary to use warm air, and under such conditions it was advisable to avail oneself of a system which would provide the hot air with the least possible trouble. The faults ascribed to artificial withering could very often be traced down to the indiscriminate use of hot air.

The investigation of the relative merits of a long wither as against a short wither was one of the basic problems of research in tea manufacture, and this question formed one item in the programme of work drawn up. It would be premature to form any conclusions until the work had been completed, but he assured the meeting that the investigation of this problem would be approached with an open mind, and the results obtained would be impartially reported. In the meantime, Dr. Evans stated that he would be most pleased to hear something about the experience of planters who advocated a long wither, since he could see present many people who practised this system.

Mr. C. Horsfall said that his experience was that if he worked with a quick wither, a nice supple leaf was not obtained. He was, therefore, forced to adopt the policy of slow withering, and he thought that this was characteristic of the jât of leaf he had to deal with. He also had the same trouble with the blackening of the tips during a quick wither as Mr. Marsh Smith, but he would still prefer a quicker wither if he could get a supple leaf as a result of it.

Dr. Evans also pointed out that it was not possible to keep the leaf on the tats indefinitely, especially in the low-country, since decomposition of the leaf was liable to set in. It might be possible to keep it for fairly long periods at high elevations where the temperatures were low, and the decomposition did not proceed at a very rapid pace, but at low elevations this decomposition took place very rapidly, and, unless care was taken to wither the leaf in good time, the teas would suffer as a result of this putrefaction.