DEVELOPMENT OF IQF PLANTS IN INDIA

S. AYYAPPAN PILLAI
Central Institute of Fisheries Technology, Cochin - 29

The paper describes the various stages of the development of different types of IQF plants in India. Some of the machinery are partly imported such as the freezing cabinet and coupled with indigenous refrigeration machinery. Some are fully imported whereas majority are fabricated fully with indigenous components. The paper also describes the essential requirements of IQF plants for producing the latest quality products.

The conventional method of freezing fishery products was by freezing in the block form in the plate freezer. The time of freezing in such method will be 2 to $2\frac{1}{2}$ hours and in the importing countries, such blocks will have to be thawed and refrozen as IQF for retail markets. With the advent of 90 minute plate freezers the quality could be improved considerably. However, reprocessing was essential so that the quality of the end product was affected and our country was losing valuable foreign exchange. If we can produce IQF products at the production unit itself the reprocessing could be avoided with better quality of the end product with increase in the price of our products in the foreign countries. Direct production of IQF products eliminates reprocessing so that drip loss occurring during thawing and refreezing is considerably reduced. Even though IQF production had started in developed countries as early in 1965, we could not develop machinery suitable for producing IQF products till 1986. One U. S. firm viz. Lewis Refrigeration Company, Woodin Ville, Wash. had developed a continuous mechanical IQF freezer for freezing of fillets, shrimp and other seafoods products which utilises standard vapour compression refrigeration system vide Quick Frozen Food International, April 1965 (Fig. 1). The freezer consists of two independent small conveyors one above the other. The product is lightly loaded on the top conveyor, partly frozen to a pre-determined point, then fluidised on the second bottom conveyor. Fluidising refers to the semi-weightless quality of products partially suspended in the air at the point of velocity and pressure to assure ultra-rapid freezing in IQF form. Subsequently several types of IQF freezers with air flow from bottom to top and vice versa, spiral type of conveying the product, cryogenic freezing and immersion freezing with brine also came into being.

The first successful IQF plant in India was installed in Galland Seafoods,

Cochin during February 1986. It was fabricated indigenously by M/s. T. Francis and Co. Cochin. It is similar to one described above (Lewis IQF unit) except that it contains a single conveyor only (Fig. 2). The air flow is from bottom to the top so that fluidisation is possible with thin product such as small size shrimp.

The second IQF plant which was installed during September 1986 in International Creative Foods, Cochin is an imported unit (APV-Parafreeze UK). The refrigeration system used is of indigenous make. This unit also has got fluidising arrangement at the beginning of the conveyor. Progressing further the air flow is from top to bottom and it has got one conveyor only.

The third unit which was installed in Coromandal Fisheries Pvt. Ltd., Kakinada during November 1986 is a fully imported unit. The unit is Mini-spiral M. 150 F. manufactured by M/s. Fuji Testsumo Co. Ltd., Japan, is a spiral type unit with built-in refrigeration system.

Subsequenty several IQF plants both imported and indigenous makes had been installed and so far more than thirty units had been installed and approved by the Export Inspection Agency. More than a dozen units are in the process of installation. Figures 3 and 4 show the arrangement of the different types of freezers.

The method of freezing adopted in the above mentioned units are by cooled air, the air being cooled by the conventional vapour compression refrigeration system. The air flow through the conveyor belt is either from bottom to top or from top to bottom depending upon the individual design. The refrigerants used is ammonia in the majority of the units. In some units Refrigerant-22 is used.

One firm viz. Olathupurath Industries (Regd.) Munambam, Cochin had installed an IQF unit using brine freezing system imported from Italy during August 1988. In this unit inside an insulated stainless steel tank, brine is kept at -21°C by keeping the stainless steel evaporator plate at the bottom of the tank. Two mixing motors have been provided to circulate the brine around the evaporator plate and stainless steel, basket filled with the product to be frozen, kept in the circulating brine. The unit is compact and the refrigerant used is R -22. Fig. 5 shows the general arrangement.

One firm viz. Triveni Foods Products, Calcutta had installed during April 1988 an IQF unit using liquid nitrogen spray system which was an imported unit and supplied by Indian Oxygen Ltd. Calcutta. The unit consists of an insulated tunnel with S. S. conveyor just like an ordinary air blast freezer but without any evaporating coil. The freezer unit (Fig. 6) incorporates three zones viz. precooling zone, spray or freezing zone and temperature equilibrium zone. The precooling zone occupies approximately one half of the overall length of the system and is equipped with four turbulence fans. These fans impart a high velocity to the cold gaseous nitrogen moving it countercurrent to the incoming food products and extract the greatest amount of referent energy (about 50%) from the vapours. An exhaust blower is connected at the feed end of the freezer to remove nitrogen vapours that have been expanded in the freezing process.

In the spray zone, the food products are exposed to finely divided droplets of liquid nitrogen which vaporise on contact with the food articles, causing a lightning fast reduction in temperature and thereby freezing the products. A series

of nozzles mounted on a spray header or manifold distribution high velocity droplets of liquid nitrogen throughout the zone.

The temperature equilibrium zone is isolated by ourtains and is equipped with a counter rctating circulation fan. In this zone, the surface and core temperature of the product approach equilibrium prior to discharge from the freezing system.

In order to obtain the best quality IQF/product several requirements will have to be met. In the case of air blast system irrespective of whether it is a straight tunnel or spiral type the plant should satisfy the conditions stipulated below.

1. The temperature of air inside the freezing tunnel should be maintained below –40°C throughout the freezing process. With a well designed plant the temperature of air will be lowered to –45°C within two hours. Once the products to be frozen are fed to the conveyor it is seen that the temperature of air rises by 2 to 5°C. It is quite natural as the heat load on the air is increased by way of freezing the product. Hence the refrigeration machinery should be such that even while the product is fed and freezing takes place continuously the temperature of air should never rise above -40°C.

2. In course of time the evaporation coil of the unit will be covered with frost due to moisture from the atmospheric as well as from the wet product so that in about 5 to 6 hours time a thick layer of frost will be built on the evaporator coil reducing the heat transfer from the evaporator coil to the air. Hence the evaporator coir will have to be defrosted with water spray or hot gas defrosting depending upon the system provided. During defrost operation the temperature of air will rise so that the refrigerant supply may be stopped during defrosting time. The defrosting should be done completely before restarting the plant. If defrosting is not done completely the ice pieces will be sticking to the coil and refrosted when refrigerant is again passed through the coil. Defrosting will take half an hour to 1 hour. After defrosting is carried out the refrigerant flow can be resumed and it will take another half an hour to one hour again to bring down the temperature to below –40°C. Th e product should not be fed unless the temperature of air is lower than -40°C and it has to be ensured that as long as the procuct is fed and freezing takes place the air temperature should always be lower than -40°C. Maintaining the air temperature below -40°C will ensure attainment of core temperature of the product to -30°C

3. As the freezing time depends on the thickness of the product, thicker the product, larger the freezing time. Typical freezing time of various products are given in Table 1. In order to vary the freezing time for various products the freezer should be equipped with a variable conveyor speed control ranging from 5 to 50 minutes (stopless).

4. All parts coming in contact with the product should be made out of stainless steel or other materials which are permitted for food products.

The following additional provisions if made will improve the quality of IQF products.

1. It is desirable to install the IQF unit in a closed room preferably air conditioned so that the temperature of the product fed to the conveyor will not rise and it is more advantageous at the conveyor outlet where the tendency of IQF product reheating cah be avoided.

2. It is a good practice to arrange the IQF outlet in the antiroom of the cold storage so that the galzing and packing can be done in the antiroom and the product can be transferred to the cold storage without any delay.

CAPACITY ASSESSMENT

Capacity assessment is done only after verifying the air temperature and feeding the product and ensuring the proper freezing of the product at the stipulated freezing time. The product can be fed after ensuring that the air temperature is steady at lower than -40°C at least for half an hour. While feeding it is to be ensured that the air temperature should not rise above -40°C. Once steady state freezing is achieved continuously, the quantity frozen for a specific time say 2 hours or 4 hours may be taken out and weighed. Thus the rate of freezing in an hour can be calculated. This figure multiplied by 24 hours gives 24 hours production. However, 24 hours production cannot be taken as the capacity of the plant in a day due to the reason that the product cannot be fed continuously for 24 hours at a'stretch. As mentioned earlier the initial cooling to bring down the air temperature to lower than -40°C will take about two hours. Then we have to wait for half an hour to maintain at the lowest possible temperature. After working for 6 hours defrosting and recooling have to be carried uot which will involve about one to two hours. Taking into account all the above factors, it can be seen that the actual porduction will be limited to about 15 hours in a day. This was discussed at a high level committee constituted by MPEDA in which the Seafood processors and IQF unit manufacturers were represented and the committee decided unanimously that the maximum capacity per day of all IQF units working on air blast system may be fixed as 60% of 24 hours production.

The above formula has been adopted to determine the capacity of IQF units using air blast system. The capacity of an IQF unit mainly depends upon two factors viz. the refrigeration capacity of the condensing unit and the holding area of the freezing cabinet. The other factors such as the air temperature and freezing time are fixed. Hence in order to increase the capacity of a unit both the main requirements will have to be met viz. the increase in refrigeration capacity which depends on the capacity of the condensing unit and the increase in the holding area of the cabinet. Of late it has been observed that the IQF manufacturers are going for higher capacities of condensing units claiming higher capacity of production per day without increasing the holding area of the cabinet. While providing higher capacity condensing unit the IQF production capacity cannot be increased unless the holding area of the cabinet is also increased. On a study of the various IQF units assessed and approved so far it is seen that in tunnel type IQF unit with single conveyor system the maximum capacity per day production possible with shrimp/prawn has been arrived at 430 kg/m² (40 kg/sq. ft.) of holding area of the cabinet. Thus it is

seen that for increasing the capacity either the length or breadth of the belt or both will have to be increased in commensuration with the increase in the refrigeration capacity of the condensing unit.

Till recently only shrimp and prawn were frozen in IQF units so that the capacities were assessed for these items only. Now several other seafood products such as squid (whole), squid tube, cuttle fish (whole), cuttle fish and squid fillets, lobster (whole), lobster tail etc. are being frozen in the IQF units. So there is a need to assess the capacities for these products also. Eventhough it seems that the same capacity rating as as that of shrimp and prawn can be considered, it is seen from the recent assessments with these products in some of the IQF units that in some cases the actual production capacities are less than that of shrimp and prawn due to the reason that non-uniform shape of such products does not permit higher density of loading of the product on the belt compared to shrimp and prawn. Moreover, the freezing time has to be increased to that of the thickest prodoct even when assorted products with thin products are fed to the freezer. The study shows that the same capacities as for shrimp and prawn can be given for squid-whole cleaned and squid stuffed with tentacles, lobster whole (cooked). For other items such as cuttle fish (whole) squid tubes, cuttle fish and squid fillets, lobster tails etc. the capacity can be taken as 75%. Products like mackerel, seafood mix (cocktail), squid ring, squid tentacles etc. The capacity can be taken 50% of the capacity for shrimp/prawn.

APPROVAL AND CAPACITY ASSESSMENT WITH BRINE FREEZING SYSTEM

With a brine freezing system freezing takes place by immersion of the product in the chilled brine maintained at-21°c. It is not possible to bring down the temperature of brine to below-40°C as in the case of air blast system as the brine will be solidified at such low temperature. It is not essential also as the water is the best heat conductor and the heat transfer from the water to the product is very fast compared to air. As the product is not in single layer as in the case of air blast system and since the product is completely immersed in brine the freezing time is almost fixed at 20 minutes irrespective of the grade in the case of shrimp/prawn. So far only whole shrimp and headless shell on shrimp had been used in this system and assessed the capacity. It has been observed that the core temperature of the product reaches-18°C in 20 minutes time with brine at-21°C. The capacity assessment in the system is slightly different from that of the air blast system. As it is a batch type arrangement the freezing per hour cannot be easily worked out. Hence a full day's production carried out from the time the product is loaded to the brine tanks and the time taken for several batches per day for freezing. Then the average freezing rate per hour can be arrived at. As the evaporating coil is immersed in the brine tank no defrosting of the evaporation coil is required as in the case of the air blast system. The only period during which the time is lost is the initial cooling which may take one or two days for the brine to be cooled to-21°C. Hence the capacity per day is taken as 20 times the average production rate per hour.

APPROVAL AND CAPACITY ASSESSMENT OF LIQUID NITROGEN FREEZING SYSTEM

In the liquid nirogen freezing system there is no major moving parts except the

conveyor and a few number of fans. There is no condensing system comprising compressor, condenser, cooling coil etc. But a vaccum insulated liquid nitrogen storage tank is essential to store sufficient quantity of liquid nitrogen. As the liquid nitrogen is boiling at-196°C the time required to freeze the food product is much shorter compared to air blast freezing. Almost all grades of shripm and prawn can be frozen in the range of 6 to 10 minutes. As no defrosting is involved compared to the air blast system the capacity per day can be assessed by by multiplying the freezing rate per hour by 20.

In the liquid nitrogen freezing system eventhough the gaseous nitrogen is not toxic, the oxygen depletion can cause suffocation to the workers. Hence the room in which the liquid nitrogen freezer is installed should be provided with sufficient number of exhaust fans to remove any nitrogen which escapes from the cabinet to the room. Eventhough liquid nitrogen freezing system is the best method of producing IQF products the running cost is very high. It has been observed that theconsumption of liquid nitrogen is at the rate of 1.2 kg of LN_2 per kg. of product frozen. Hence unless liquid nitrogen is available at reasonably low cost the process cannot be economical.

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Table 1
Typical Freezing Time of Various Fishery Products with Air Blast System

Product	Freezing time at air temperature maintained below -40°C
P & D Shrimp	
(count - 600)	6 minutes
-do- (count 250-300)	7 ,,
-do- (count 100-200)	8 ,,
-do- (count 80-120)	10 ,,
-do- (count 60-80)	12 ,,
-do- (count 51-60)	
-do- (count 41-50)	15 minutes
-do- (count 31-40)	
-do- (count 16-20)	18 ,,
Headless shell on prawn	
(count 71-90)	12 ,,
(count 61-70)	
(count 51-60)	15 ,,
(count 41-50)	
(count 36-40)	
(count 26-30)	
(count 21-25)	
(count 16-20)	20 ,,
(count 13-15)	30 ,,
(count 6-8)	45 ,,
Scampi (count 6-8) (whole)	45 ,,
Cuttle fish (whole) (count 13-20)	25 minutes
-do- (count 8-12)	30 ,,
Cuttle fish fillet/Squid fillet (count 40-60)	20 ,,
-do- (count 21-30)	
Squid tube (count 40-60)	20 ,,
-do- (count 10-20)	25 ,,
Squid tube stuffed with tentacles (count u/10)	30 ,,
Squid tentacles (assorted)	25 ,,
Squid ring (assorted)	10 ,,
Cooked lobster (whole) (count 200-300 gm per piece)	50 ,,
Lobster tail count 16-20)	30 ,,
Seafood mix (cooktail)	10 ,,
Mackerel (count 8-10 per kg)	50 ,,
Pomfret (whole) 300-500 gm per piece	45 ,,
Seer fish steak (assorted)	40 ,,
Seer fish fillet	45 ,,

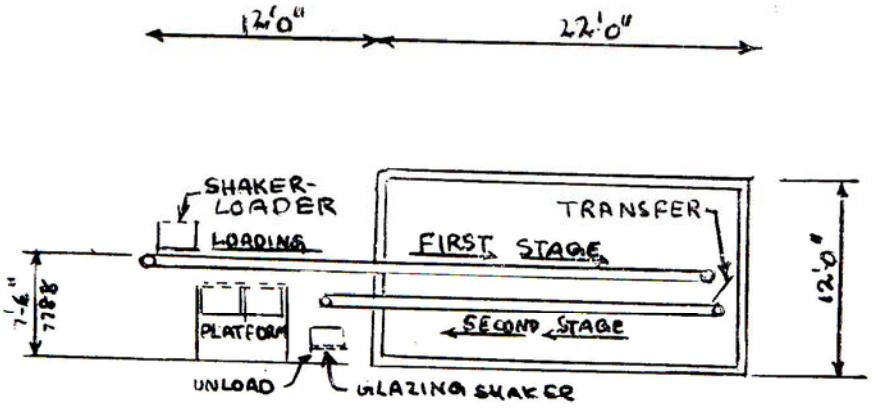

FIG. 1 . FLUIDISED IQF MACHINE

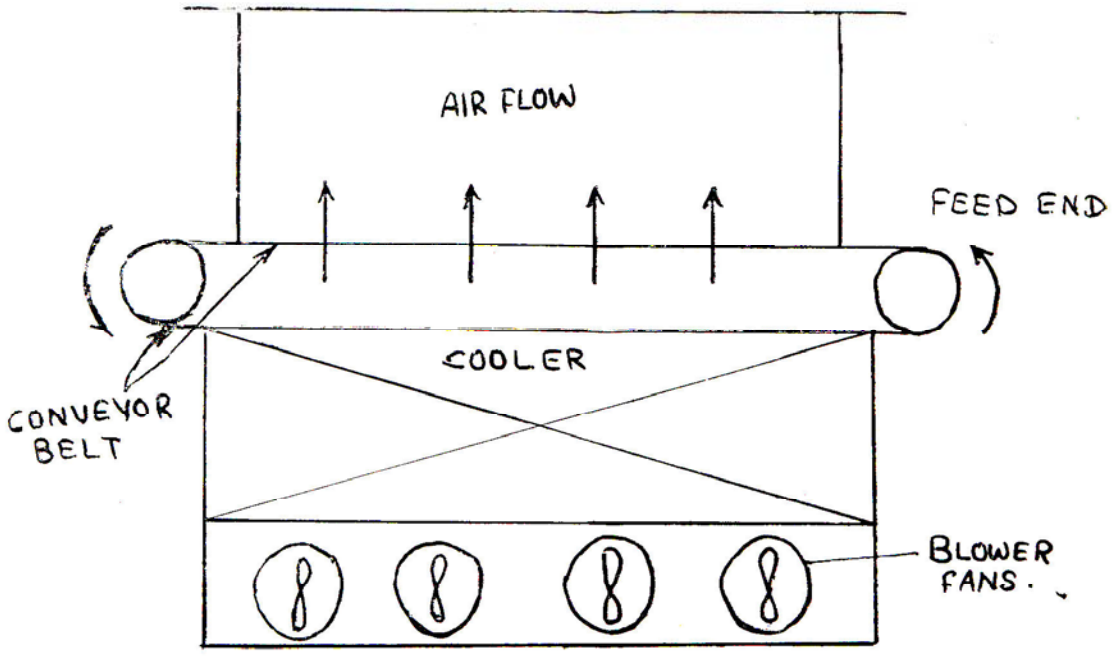

FIG. 2. THE FIRST INDIGENOUS IQF MACHINE

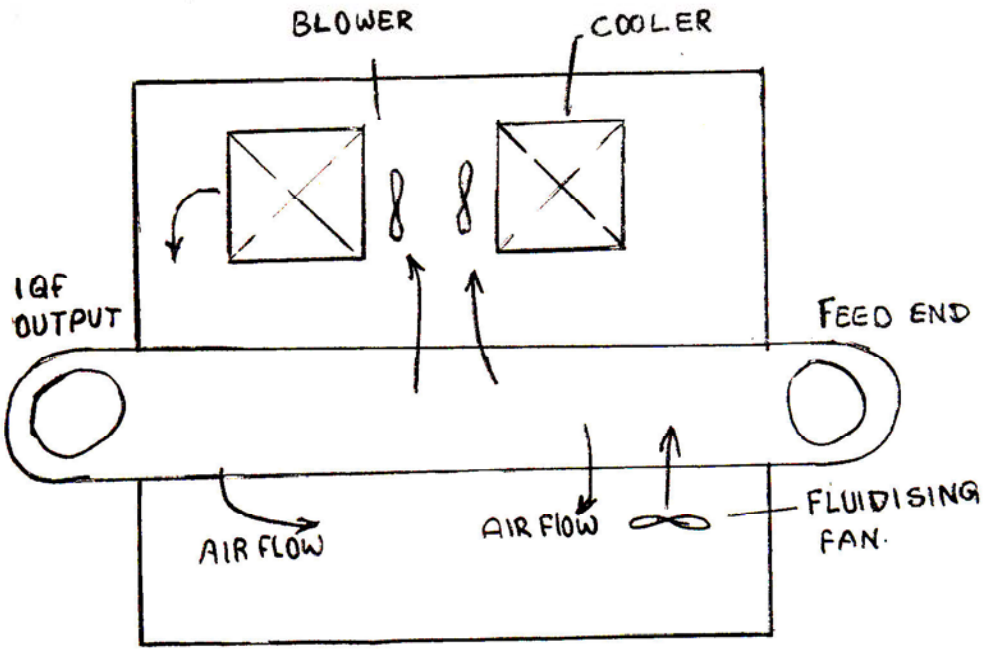

FIG. 3. DIAGRAMATIC VIEW OF APV-PARAFREEZE IQF MACHINE.

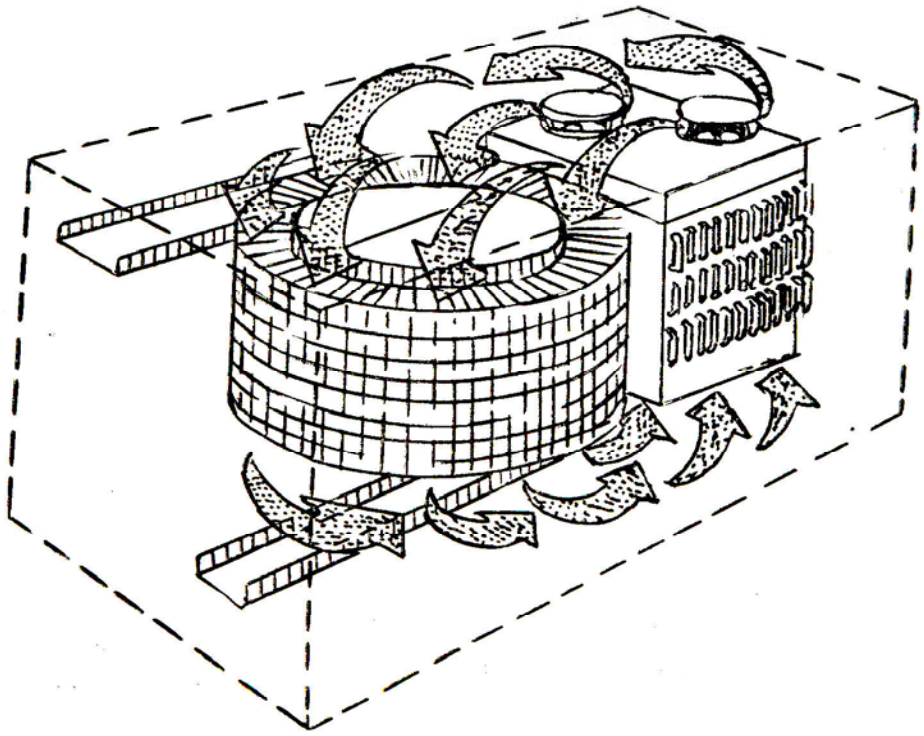

FIG. 4. SPIRAL TYPE OF MACHINE

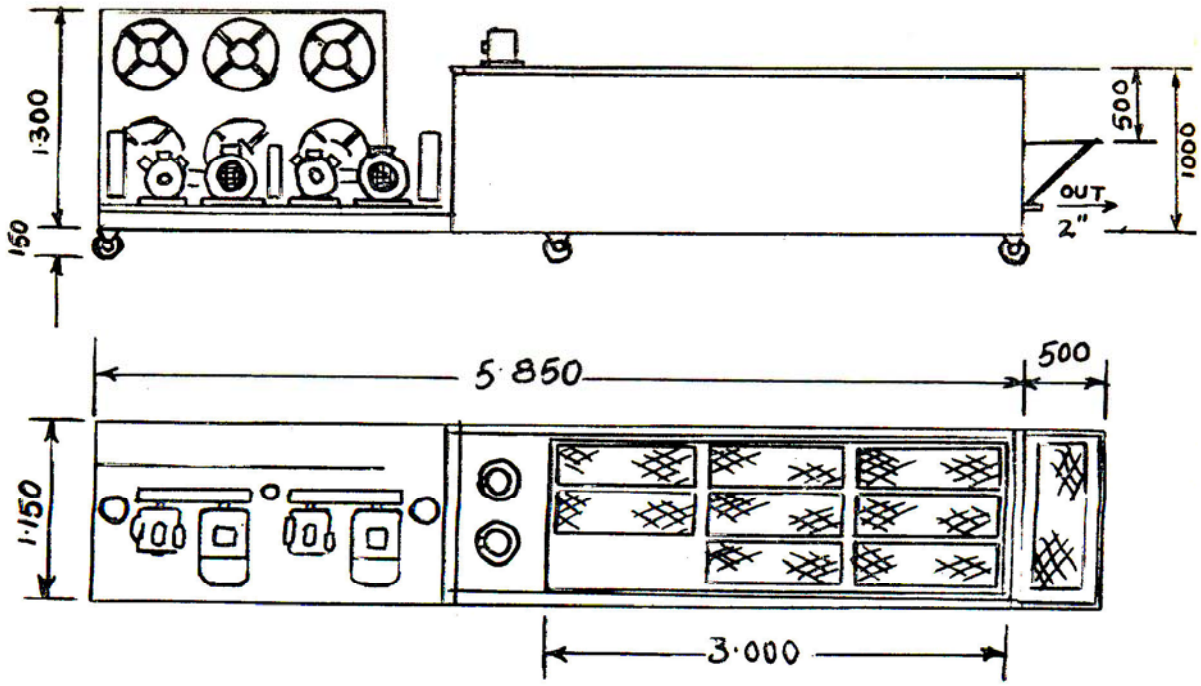

FIG. 5 IMMERSION TYPE IQF MACHINE.

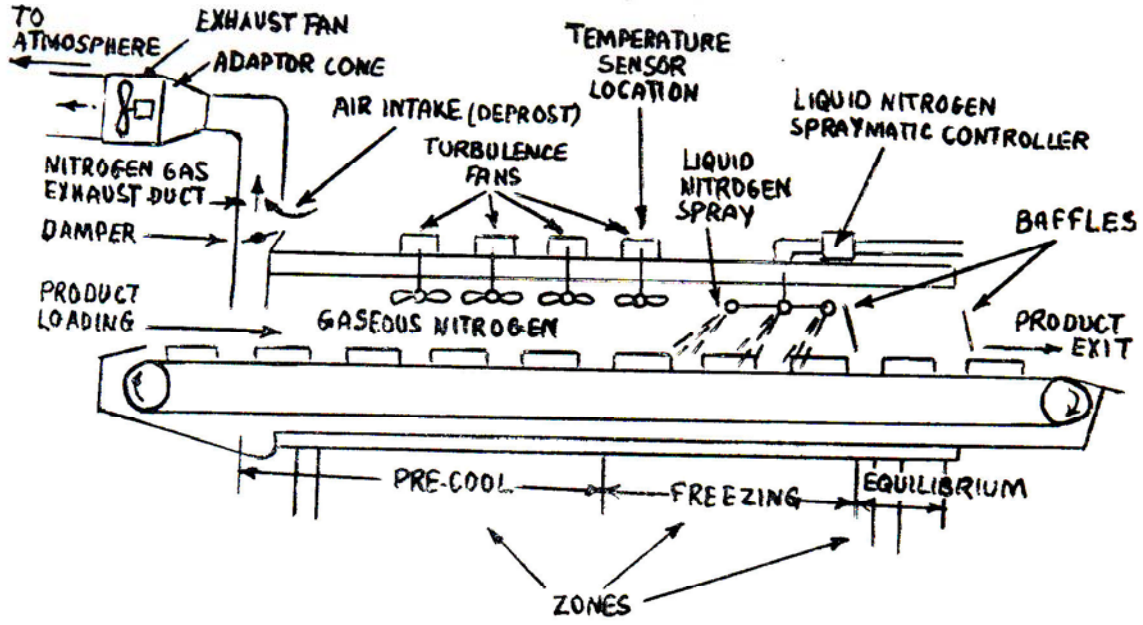

FIG. 6. IQF MACHINE USING LIQUID N_2.