June 14, 1949. C. D. COTHRAN 2,472,794

REMOVAL OF SURFACE MOISTURE FROM WET ARTICLES

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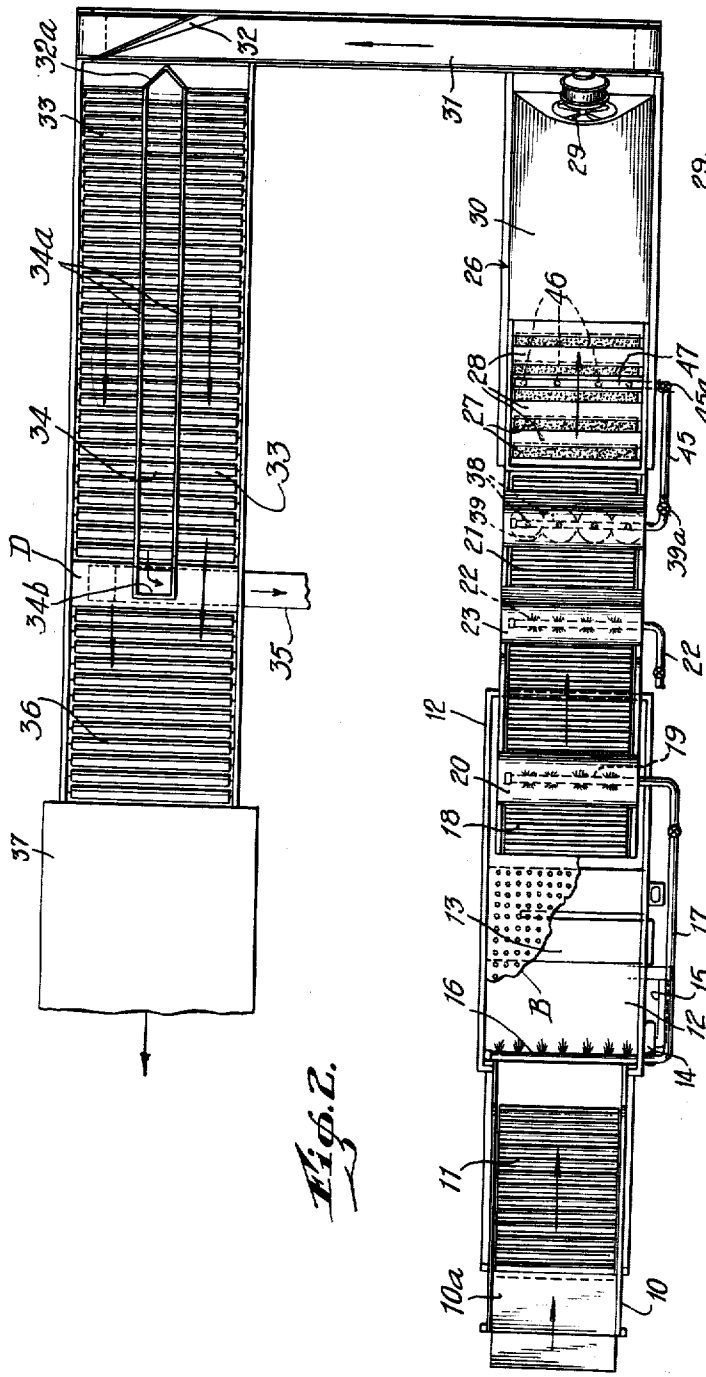

Fig. 2.

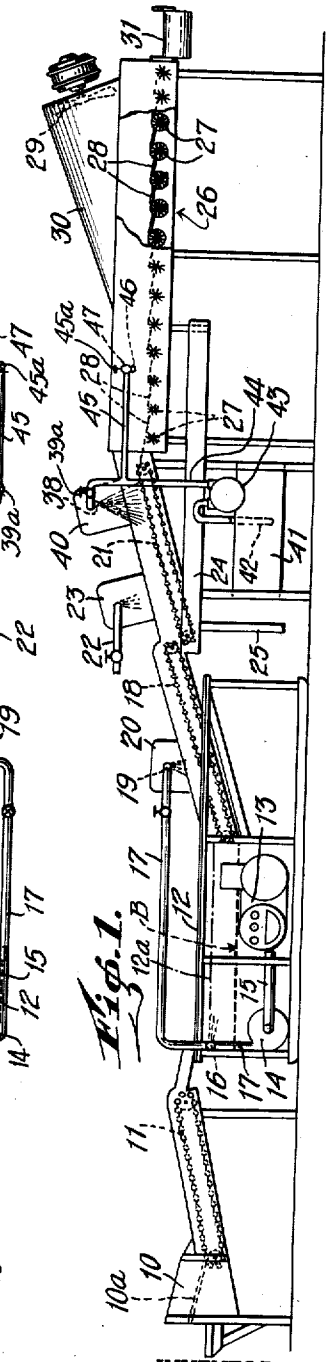

Fig. 1.

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REMOVAL OF SURFACE MOISTURE FROM WET ARTICLES

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1

This invention relates to removal of surface moisture from wet articles. More particularly it relates to a process of removing surface moisture from fruits and vegetables, such as citrus and deciduous fruits, tomatoes, and the like, that are wet with water or aqueous liquid clinging thereto, which includes applying to the wet articles a surface-tension reducing agent in such manner as quickly to eliminate from the surface of the articles, in a relatively simple and inexpensive manner, a substantial proportion of the adherent water or aqueous liquid, this being done usually but not necessarily as a step preliminary to further treatment of the articles in any conventional or other suitable manner adapted to accomplish surface-drying thereof completely or to such extent as is necessary or desirable in preparing such articles for packing and shipment to market, thereby expediting such further surface-drying treatment and also rendering it more effective and economical.

In its most useful practical embodiments, the process of the invention may be generally characterized as an improvement upon the broadly old and well known type of procedure wherein articles are, for one purpose or another (e. g. cleansing), contacted with water or an aqueous liquid in large volume and, after discontinuance of such contacting, are surface-dried to substantially free them of sensible moisture; such surface-drying being accomplished either positively through employment of special evaporating means, or simply by exposing the wet articles to normal atmosphere. In the improved procedure of the invention, use is made of a surface-active agent for the purpose of reducing the surface tension of the aqueous liquid adhering to the articles after the aforesaid discontinuance and causing it to film out over their surfaces, thereby promoting rapid run-off of liquid from the articles and leaving less liquid to be evaporated off in the ensuing surface-drying. But achievement of this result by adding sufficient surface active agent to the large volume of aqueous liquid with which the articles are contacted in the surface treatment mentioned is ordinarily quite impractical for reasons of economy if for no others. In contrast, the procedure of the present invention involves applying the surface active agent to the wet articles after the cleansing or other aqueous liquid treatment has been completed, and in such manner that the desired filming-out and run-off of the still adhering aqueous liquid can be accomplished with an expenditure of only a small percentage of the amount that would be required to produce such result if the surface active agent were added to the aforesaid large volume of aqueous liquid.

2

Although the invention may be usefully employed in other fields, its importance in the fresh fruit and vegetable packing industry is outstanding, and its employment in that field will therefore be referred to and described more particularly hereinafter by way of illustrative example in explaining the principles of the invention.

Fresh fruits and vegetables that are to be packed for shipment to market commonly have to be washed to cleanse them from adherent dirt and other foreign matter which they carry as they are received at the packing house. Frequently they are also treated, either as a part of the washing operation or in a succeeding step, with an aqueous solution of a mold-inhibiting agent, more especially borax, as a safeguard against decay. In practice, this washing operation usually includes advancing the fruit or vegetable articles through a large wash tank containing warm water to which alkaline detergents of various kinds have been added. Contacting the articles with this large volume of cleansing liquid, an operation which often includes rubbing them with revolving brushes, loosens the adherent foreign matter and facilitates its removal. The wash water thus becomes foul rapidly, necessitating frequent dumping and renewal thereof. Operations in the cleansing zone usually also include liberal rinsing of the articles with fresh (clean) water after they are removed from the wash tank, in order to flush off all adherent dirty wash water. Whether or not a protective coating of waxy or other material is to be subsequently applied in the course of the packing operations, the wet fruit or vegetables must be surface-dried (i. e. freed from sensible surface-moisture) after they leave the cleansing zone, if only as a decay-prevention measure, before being packed into boxes or other containers for shipment to market. Where application of a protective or luster-producing coating by a non-aqueous method is included in the packing house operations, this surface-drying immediately precedes the coating operation, and it is essential to most effective performance of said coating operation that the surface-drying be as complete as possible.

Consequently, as is well known to those versed in the art, the proper surface-drying of fresh fruits and vegetables at one stage or another of their progress through the series of operations to which they are subjected in being prepared for market in the modern packing house or plant, is

a vitally important matter. Moreover, as is also well known, the problem of accomplishing this surface-drying effectively and economically has proved difficult to solve satisfactorily, despite the expenditure on the problem, throughout many years, of a vast amount of skillful and inventive effort and ingenuity. This is due in large part to the perishability and sensitiveness to injury characterizing the products or commodities to be surface-dried, and the strict limitations which these considerations alone, aside from others, immediately impose upon the choice of available drying methods, as well as upon the character and design of apparatus and equipment for carrying any method out practically. Among other things it is obviously essential, in order to avoid injuring the products being handled, that the drying shall be effected at relatively low temperatures and minimum cost, requirements inherently incompatible with the further practical requirement that in large scale commercial operations the desired thorough drying should be accomplished rapidly.

Thus, despite the general and long-continued recognition of the existence and seriousness of the problem and the persistent effort to work it out, no really satisfactory solution of the problem has heretofore been available. Such progress as has been made toward the goal during the several decades since the systematic commercial handling of fresh fruits and vegetables through packing houses for shipment to market began to give promise, early in the present century, of becoming a large scale industry in this country, has involved for the most part merely detailed mechanical variations in certain types of drying apparatus which, from the first, became more or less standard in the industry and have persisted virtually unchanged in fundamental operating principles down to the present time. In general, such drying apparatus has comprised conveyor means of one kind or another for advancing the wet fruit or vegetables into and through a long drying zone, wherein the articles are exposed to currents or blasts of air, heated or not, in order to evaporate off the adherent moisture. In one of the standard types, this alone is relied upon to accomplish the desired drying. In a second type, the wet articles are contacted with absorbent material for removal of adhering moisture, air also being blown on the fruit to aid in the drying. These two types may be said to represent the two principal lines along which fresh fruit and vegetable driers have been developed in the commercial packing industry in the hope of arriving at a satisfactory solution of the surface-drying problem.

From at least as early as 1909 down to the present time, there has been virtually continuous intensive effort on the part of numerous skilled workers in the industry, as shown by dozens of patents granted during that period, to improve the construction and operation of both types of drying apparatus aforesaid, all in the hope of rendering them more effective, reliable and efficient in operation, as well as smaller in size for a given throughput and hence lower in first cost and more economical of valuable space in packing houses. One such improvement was the replacement, early in this period, of older types of conveyers by the now commonly employed revolving roller conveyer whereon the wet articles are turned over and over as they are moved through the drier, in order more completely to expose all surfaces to the drying atmosphere. Another was the provision of means enabling more direct application of drying air currents or jets to the wet articles and, in general, more systematic circulation of drying air throughout the apparatus. It was also proposed at an early date to take a part of the load off the drier by interposing ahead of it a special auxiliary unit whose function it was to remove from the wet articles, by mechanical means of one kind or another, some of the surplus or more readily removable portion of the water clinging to the wet articles, thus leaving less to be evaporated off in the drier. This type of auxiliary unit, eventually known as a water "eliminator," itself has provided basis for much inventive development during the last decade especially, as shown by numerous patents, evidently because the industry believed that in perfecting such auxiliary mechanical water eliminators lay the best and perhaps the only hope of getting the regular drier to do at least a reasonably good job of drying.

Any detailed review of the prior art history, briefly touched upon hereinabove, shows a full realization by the art workers, more than thirty years ago, of the problem with which the present invention is concerned and the pressing need for a satisfactory solution of it. It also shows the persistent, varied and often ingenious efforts by workers in the art, throughout more than three decades, to find such a solution, and their admitted failure to do so. Much the same complaints concerning the failure of all prior drying apparatus to accomplish effective drying, its undesirably great size (often 100 feet long) and the excessive amount of floor space consequently required to accommodate it, its complexity, its high first cost and subsequent large expense of operation and upkeep, and so on, appear over and over again in the many patents granted during that long period on driers and eliminators. That these and other difficulties and drawbacks still persist to a great extent after many years of earnest effort to overcome them, is evident from what is said in some of the later patents such, for example, as Keech 1,991,324, Paxton 2,145,495, Currie 2,220,197 and Grant 2,317,144, and in any event is common knowledge in the industry. Moreover, the attempts to overcome these long-standing troubles, have in some instances introduced new ones peculiar to the proposed cures. Thus, the use of metal (brass) surfaced water eliminator rolls and cooperating squeegees, gives rise to noisy "screeching" which is "loud and very weird," according to the patents to Paxton et al. 2,159,046 and Stebler 2,267,429, a difficulty which these patents propose to overcome, the former by abandoning such devices in favor of rotary brushes, the latter by filling the hollow brass shells forming the eliminator roll surfaces with sawdust.

Thus, despite all the skilled thought and effort expended during the last 35 years in trying to find a real solution of the problem, it is manifest that no notably important progress toward that goal has heretofore been made. As is made clear hereinabove, practically the same old ground has been worked over and over; and aside from various mechanical refinements which themselves often give rise to increased complexity and cost of both construction and operation of drying equipment, the art of drying fresh fruits and vegetables in preparation for market remains basically in pretty much the same condition it was in 1910, with virtually none of its then characteristic basic difficulties satisfactorily overcome. It still remains a fact that the drying system or equipment, besides constituting as a

rule the largest and most expensive item of fruit and vegetable packing house apparatus in respect both to first cost and subsequent upkeep, is ordinarily also still more or less erratic and otherwise unsatisfactory in its performance and the source of many operating troubles, even under normal operating conditions, and that these difficulties are especially great in cool or damp weather. It is not uncommon to find fruit leaving the drier with visible droplets of water on its surface, and sometimes almost as wet as when it entered. Fruit or the like packed into shipping containers in this condition is almost sure to suffer heavy decay in transit to and after arrival at marketing destination, with resultant loss to the shipper. Nor, if waxy or other protective or luster-producing material be applied to such wet or insufficiently dried articles by a non-aqueous method, as by atomizing the coating material thereon in hot molten condition or dissolved in a non-aqueous solvent, can as satisfactory a coating be produced as when the articles have first been properly freed of all sensible surface moisture.

In connection with the problem of preventing acidulated rinse water from being retained in the stem and blossom end depressions of apples carrying arsenical spray residues and, in the subsequent surface drying of the apples, from forming a sufficiently strong acid solution to dissolve arsenic left in those depressions and thereby cause injury to the fruit, it was long ago proposed to add to the rinse water, which was contained in a dip tank through which the apples were passed after leaving the acid-wash tank and which become increasingly acid from continued passage of fruit therethrough, a colloidal material, preferably casein or other protein, that would lower the surface tension of the acidulated rinse water. This addition of casein, it was said, would cause the acidulated water and other harmful substances left on the rinsed apples to be drawn from the aforesaid depressions and spread so thinly over their surface as to obviate danger of damaging the fruit, and would at the same time expedite the drying operation. It may be noted, in passing, that complete surface drying of apples to be packed is not necessary, due to characteristics more or less peculiar to apples, and in actual practice is therefore usually neither desired nor attempted. In order to save expense, it was said to be permissible to substitute for the casein, wholly or in part, certain specified non-protein gummy materials which were recognized, however, to be much less effective for the purpose.

This proposal proved to be wholly impractical for various reasons, and has been entirely without effect upon the art of preparing fresh fruit and vegetables for market. Even in the particular form proposed, which involved adding one or more of the above materials to the comparatively limited volume of repeatedly used rinse water in a dip tank, and disregarding the unsanitary and other objectionable conditions which the use of such materials in this manner would inevitably produce in the drier installation and other parts of the packing plant, the method would probably be too expensive if casein were employed in the quantity necessary to produce the desired result, because of the practical necessity for frequently re-charging the tank with fresh water containing casein. In any case, the expense at once becomes definitely prohibitive if the washed apples, instead of being rinsed by

dipping in a progressively more and more contaminated body of rinse water, are flood-rinsed by means of clean water sprays, in the manner required in order to keep within the tolerance limit set by official regulations with respect to the amount of poisonous residues permissibly carried by fruits and vegetables to be marketed.

In the case of such fruits as apples and pears which are commonly heavily loaded with arsenical spray residues when brought in from the orchard, such required rinsing after washing means spraying from 15 to 25, or even as much as 50, gallons of "fresh" (i. e. clean or uncontaminated) water per minute upon the stream of fruit as it is moved along at average normal speed, one layer deep, on the conventional roller conveyer (usually 4½ to 5 feet wide) which carries it from the washing tank to the drier installation. In some cases, as much as 100 gallons per minute must be used. Other fruits, such as oranges, lemons, grapefruit and tangerines, commonly require less fresh water rinsing because, ordinarily, they carry much smaller deposits or residues of poisonous insecticides. However, they usually have to be washed with the aid of detergents to remove adherent dirt, oil-smudge, scale or other insect deposits, and are generally treated with a solution of borax for decay control; so that, in order to avoid giving the surface-dried fruit a dull or dusty look, due to solid matter suspended or dissolved in the washing or treating liquid which adheres to the fruit as it travels toward the drier on a roller conveyer, a fresh water spray rinsing, amounting usually to at least 6 or 7 gallons per minute is found necessary in practice, assuming the same customary conveyer width as before. Around 10 to 15 gallons per minute is perhaps more usual. This is also typical of usual practice in rinsing washed vegetables or produce such, for example, as tomatoes, peppers, cucumbers, and potatoes; much greater quantities being frequently necessary, however.

Depending upon the particular vegetable product being handled, a conveyer of the usual 4½ to 5 foot width, operating at what may be considered a normal linear speed of about 25 to 30 feet per minute, and continuously receiving from the washing or treating tank a full supply of fruit distributed one layer deep over approximately the whole available carrying surface, will handle approximately 750 pounds of citrus fruit or tomatoes (for example) per minute. In practice, due chiefly to irregularity in rate of feed to the conveyer, operation is seldom maintained uniform at full capacity for long periods of time and is frequently at only half capacity or less for periods of varying length; but, as a practical matter, the fresh water rising sprays must nevertheless be set to operate at a substantially constant rate. Since employment of a fresh water spray rinse of from 6 to 15 gallons per minute may be taken as typical for washed citrus fruit handled on such a conveyer unit, this means that from at least 360 to 900 gallons of rinse water per hour is needed under normal operating conditions. In the case of such fruits as apples and pears, or of any other vegetable products which have to be similarly handled in washing and rinsing, the normal rinsing requirements run, on the same basis, from 900 to 1500 gallons per hour, and sometimes will go as high as 3,000 gallons per hour or more. Even at the minimum of 360 gallons of rinse water per hour, let alone when greater volumes are needed, the use of a suf-

ficient amount of a surface tension lowering agent in the rinse would entail substantial expense; while at the average and maximum rinsing rates, the expense would usually be prohibitive.

In accordance with the present invention, the longstanding problem hereinabove discussed is effectively solved through provision of a novel process which is simple and economical to employ and which, although capable of effecting radical changes in the present long-established standard practice in the surface-drying of wet vegetable products (fresh fruits and vegetables) in respect to both drying procedure and also drying equipment, can also be employed to great advantage while utilizing existing installations without change and making only a very simple and inexpensive addition to the present conventional train of handling equipment preceding such installations.

In brief outline, the novel process comprises applying to the wet articles to be surface-dried, a relatively small quantity of a dilute dispersion or solution in a water-miscible liquid carrier, which is most desirably water itself, of a surface-active substance having pronounced surface tension lowering power, and then exposing the articles to a drying atmosphere. The quantity of surface tension lowering agent or surface conditioning agent used in the applied dilute dispersion or solution, hereinafter frequently referred to as the "surface-conditioning liquid," need be only such that the resultant liquid mixture form on the surface of each fruit or other article—composed of the water clinging thereto from the preceding rinse or other wetting, plus the applied surface-conditioning liquid—will have a surface tension so substantially lower than that of the adherent water alone that the liquid mixture spreads out evenly over the surface in a thin film instead of standing thereon in drops or blobs; and this result can be accomplished with a relatively minute quantity of a suitable surface conditioner. Accompanying this thin filming out, is an accelerated drip or draining of liquid from the article which, in the best embodiments of the invention, quickly reduces the amount of adhering liquid to a residue substantially less than the amount left on the article when wet with the rinse water alone after an equally long drip or drain period. The effect just described is so pronounced that in some cases where the new method has been practiced in connection with existing drier installations, the articles are already sufficiently dry before entering the drier unit proper; whereas in operating the same installation in accordance with prior practice but under otherwise identical conditions, the articles were not sufficiently dry even after passage through the drier unit. These results are attainable by the use of a surface conditioning agent in quantity that need never be more than about 2% to 3% at the most, and in practice is ordinarily not more than from 1.5% down to 0.3% or an even smaller percentage, of the quantity which would be required to give the same effect if the surface conditioning agent were added to the rinse water or other aqueous liquid with which the articles become wet in being prepared for market and on that account have to be dried.

Accordingly, the present invention enables overcoming wholly or in large part, in a simple, effective and economical manner, troublesome difficulties which have been associated for many years with the drying of wet fruits and vegetables undergoing preparation for market, and which have so long defied continued effort to overcome or reduce them in more than relatively small degree, and even then only by increasing the complexity and cost of drying installations.

While any suitable surface tension depressant or surface active agent may be used in practicing the invention, the scope of the invention being broad in this respect, the specific character of the depressant is by no means a matter of indifference, some substances being far more satisfactory than others for the purposes of the invention. Since surface tension depressants that are most effective in their action are as a rule non-volatile at drying temperatures of the magnitude with which this invention is concerned, and since some residue thereof is therefore left on the fruit or other articles in the drying, as well as a cumulative residue on certain parts of the drying installation, the invention in its best embodiments contemplates employing a surface active agent of high specific potency, so that only a relatively very minute quantity thereof need be used in order to accomplish the desired rapid removal of excess surface moisture from the wet articles to be dried. Most desirably also, said agent should be non-colloidal in character and easily dispersible in water to a true solution of the desired low concentration.

Although practice of the novel process is not dependent upon or confined to the use of any specific type of apparatus or plant equipment, one practical form of apparatus equipment or system which has been found suitable to employ in the commercial preparation of tomatoes for market, and which is already well known and conventional save for such slight modification as is necessary to adapt it for treatment of wet tomatoes in accordance with the present invention, is shown by way of example and more or less schematically or diagrammatically in the accompanying drawings, wherein Fig. 1 is a side elevation, and Fig. 2 is a plan, of such a system or installation.

Referring to the drawings, tomatoes as they come to the packing house from the field are dumped into the feed hopper 10 having a slatted bottom 10*a* sloping to an inclined roller conveyer elevator 11, which delivers them into soaking or wash tank 12. While the tomatoes are on their way to said tank, most of the accompanying trash and any loosely adherent soil or dirt fall through said slatted bottom and the spaces between the conveyer rollers and thus are largely separated from the tomatoes before they reach the tank. The tank is nearly full of wash water, the level of which is indicated at 12*a*. The water may be heated by means of submerged heater 13 and circulated by means of rotary pump 14 whose intake 15 is adjacent the heater. Through the body of wash water above the perforated baffle plate B extending horizontally over the heater, the tomatoes are propelled toward the opposite or discharge end of the tank in any suitable manner, e. g. by pressure jets of wash water supplied by the pump to jet pipe 16 through discharge line 17. Arriving at said opposite end of the tank, the tomatoes are picked up by inclined roller conveyer elevator 18 which carries them up out of the tank. While being so removed, they are sprayed with warm wash water supplied through valve-controlled line 17 to spray pipe 19 in hood 20, the spent spray draining back into the soaking tank. Elevator 18 then delivers the washed fruit to rinse elevator 21, whereon the fruit is rinsed thoroughly with fresh (i. e. clean, uncontaminated) water showered down upon it by valve-controlled spray pipe 22 in hood 23, the spent

rinse water falling into pan 24 and going to waste through outlet pipe 25.

In the prior practice, the fruit, wet with rinse water, was then delivered without further treatment to a drier unit 26 of any suitable type which, in the present illustrative example, is shown as a combined eliminator and drier unit of the general type of construction disclosed in the patent to Cunning 2,199,831, wherein transverse rotary brush rolls 27 alternate with oscillating brush or metal lifters 28, the latter operating to advance the fruit over successive brush rolls in the direction of the arrow, while drying air, heated or unheated, is blown down on the advancing fruit by fan 29 mounted in hood 30.

Tomatoes discharged from the drier are received upon a horizontal endless belt conveyer 31, from which they are diverted by adjustable sheer means 32 and directed by distributer 32a to the two outer longitudinal sections 33 of a table of usual type, on either side of the central cull section 34 lying between the longitudinally extending upright division boards 34a. On opposite sides of this grading table on which the tomatoes are continuously advanced, stand operators who grade out culls and place them in the centrally disposed cull section 34 of the conveyer which discharges them through an opening 34b in delivery board D down upon transverse cull belt 35 located between the upper and lower runs of the roller conveyer and discharging to a cull bin (not shown). Marketable grades are delivered by the conveyer sections 33 over delivery board D to roller conveyer elevator 36, by which they are fed, in this instance, to a hot waxing and polishing unit 37 similar, for example, to that disclosed in the patent to Skinner 1,830,297 of 1931 but employing, if desired, transverse rotary brush rolls and oscillatory lifters in accordance with Patent 2,199,831 to Cunning, already mentioned. In unit 37, molten waxy material is atomized upon the tomatoes in a heated environment and spread thinly over their surfaces to provide a film-like protective coating, all in well known manner. The waxed tomatoes then go to further conventional apparatus (not shown), wherein they may be sized and perhaps further graded or otherwise finally readied for packing into lugs for shipment to market.

Such an apparatus system, as thus far described, is old and well known in the art, as are also the various packing house operations carried out with the aid thereof. This typical prior practice is explained in detail here only for the purpose of helping to make clear the relation of the present invention thereto, as well as the ease with which practice of the invention may, where desired, be superimposed upon prior practice without disturbing the latter, or without materially changing it except for improving substantially the results obtainable in respect to or in connection with surface drying.

In applying the present invention to the handling of tomatoes through such a packing plant as that described hereinabove, a plurality of suitable spray or atomizing heads or nozzles 38 may be carried by a supply pipe 39, valved at 39a, which is mounted within the hood 40 to extend horizontally above and across the rinse and drain conveyer 21, at a location between the fresh water rinse 22 and the intake end of eliminator and drier unit 26. A solution or dispersion of a suitable surface tension depressant, in predetermined concentration ordinarily very small, is pumped from supply tank 41 through pipe 42 by pump 43 and

forced through pipe 44 to pipe 39 and the atomizing heads carried thereby. For a purpose to be referred to hereinafter, there may optionally be provided a branch supply pipe 45, valved at 45a, through which the conditioning solution or dispersion may be supplied either alternatively or simultaneously to a second set of atomizing nozzles 46 carried by pipe 47, positioned transversely over the rotary brush rolls and lifters of the initial or "eliminator" section of the drying unit 26.

It will be seen that, after being thoroughly rinsed with fresh or clean water from rinsing spray pipe 22 which, in a unit of the size assumed, normally showers around 10 to 12 gallons of rinse water per minute down upon the fruit traveling thereunder at a rate of, say, 300 to 750 pounds per minute, the dripping wet tomatoes are then carried by elevator 21 under the hood 40, wherein they are contacted by surface conditioning solution that is continuously sprayed upon them in much smaller quantity from the nozzles 38. The action of the revolving conveyer rollers upon the tomatoes, whereby the fruit is constantly turned over and over to expose all surfaces thereof to the conditioning spray, enhances rapid and uniform distribution of the surface conditioning agent. As a result, the applied surface conditioning liquid quickly commingles with the water still clinging to the fruit, including any discrete drops, and the mixture promptly films out so thinly over the fruit surface that only a portion of the water normally capable of adhering thereto can be held, the rest quickly draining from the fruit by gravity and being caught by the pan 24, along with some of the surface tension depressor or conditioning agent, and run to waste. Collection of these drainings separately from the spent fresh water rinse, for re-use, is not ordinarily to be recommended. This is because it is desirable, for maximum uniformity of operation and simplicity of control in practical use of the new process, that the composition of the liquid supplied to nozzles 38 remain constant. Re-use of said drainings would of course result in progressively decreasing the concentration of the surface active agent in the liquid supplied to nozzles 38, and hence in undesirably varying its conditioning effect. Provision could be made, of course, for properly readjusting such concentration, but this would involve trouble and expense ordinarily not warranted in view of the small saving effected in cost of conditioning material.

It is advantageous to space the surface conditioning spray means 38 sufficiently far from the preceding fresh water rinse sprayer 22 to permit natural draining of rinse water from the wet articles to occur for at least a brief interval before the conditioning spray is applied. This leaves less adherent water to mix with the small amount of solution or dispersion of the surface tension depressor that is subsequently applied to the articles, thereby enabling a saving in the amount of such agent necessary to use in order that the aqueous mixture on their surface shall contain said depressor in sufficient concentration to produce the desired filming-out effect and accelerated water run-off from said articles. A still longer period for draining or drip of surplus rinse water from the wet fruit, prior to application of the surface conditioning solution, is afforded if valve 39a is closed and valve 45a is opened, whereby said solution is applied to the fruit through nozzles 46 only. This has the further advantage that the brush rolls 27 act immediately, at the instant said solution is applied,

to mix the solution with the residual water on the fruit rapidly and completely, in a manner particularly effective to cause quick and uniform filming-out of the mixture over each fruit and release most of it as drip or run-off which falls into pan 24.

Where the conditioning agent is applied through nozzles 38, as initially assumed, and where the articles are not already substantially dry by the time they have reached the entrance to the drying unit 26 as a result of the water releasing and removing action of the applied surface tension depressant, the wiping action of the rotating brushes 27 is advantageous and important in furthering uniform distribution of the surface conditioning agent throughout the residual adhering liquid, and hence increasing its effectiveness in filinmg such liquid out very thinly, thereby releasing the maximum amount for gravity removal as drip falling into pan 24, and thus reducing to a minimum the amount of moisture that still clings to the articles and must be removed by evaporation in the drier unit proper. The drier is found to function with markedly greater effectiveness than it does under conditions identically the same except for omission to apply the surface active agent as described. Under that former practice it was not at all uncommon for the fruit or vegetables to leave the drier still carrying visible droplets of moisture, which adversely affected the appearance and protective properties of the wax coating subsequently applied to the articles in the waxing and polishing unit 37. The much better surface drying made possible by the present novel process results in materially improving that waxing operation, thereby enabling a more perfectly adherent wax coating to be obtained and, consequently, better protection against withering or shrinkage of the fruit or vegetables treated.

Another advantage resulting from the invention, is that it becomes unnecessary to use squeegee devices or other special means for removing from the brass or brush rolls of the usual water eliminator unit, or the eliminator section of a drier unit, the water that is transferred to said rolls from the fruit; the presence of the conditioner or depressor agent in such transferred water, where there is any, causing all necessary removal of excess water from said rolls to occur automatically simply by draining. This in itself is an important advantage, since it thus becomes feasible to simplify considerably the construction of water eliminator devices where it is desired to use these, thereby rendering operation and upkeep of the water eliminator less troublesome and expensive, as well as lowering its initial cost. This advantage is aside from and in addition to that of the great reduction in length of the drier proper now made possible.

As regards the particular surface active agent to be employed, there is wide latitude for choice of such agent in practicing the present invention, as has already been mentioned generally hereinabove. However, some have been found much more suitable than others for use in actual practice, outstandingly so in certain instances. Experience with the novel process thus far indicates that certain types of water soluble synthetic organic compounds, notably those comprising esters of sulphodicarboxylic acids, particularly sulpho-aliphatic dicarboxylic acids, and especially high molecular alcohol esters of sulphosuccinnic acid, have characteristics as surface tension depressors and wetting agents which adapt them

extraordinarily well for use in actual practice of the present invention. Compounds of this type are disclosed in the patent to Jaeger 2,028,091. A number of wetting agents consisting of or comprising alkali metal salts of such esters are obtainable commercially under the trade name "Aerosol" from American Cyanamid & Chemical Corporation, New York, N. Y. Of these, the wetting agent designated as "Aerosol OT," which is marketed in various different forms all characterized by the fact that they consist of or contain di-octyl sodium sulphosuccinate, has been found to give outstandingly successful results in the practice of the present invention. A solution of "Aerosol OT" in ordinary tap water containing as little as 0.025% of the active constituent above identified has a surface tension of around 28 to 29 dynes per centimeter at temperatures approximating 70° to 75° F., typical tap water alone showing a surface tension of around 73 to 74 dynes per centimeter, under the same conditions. It is characteristic of this type of wetting agent that the small content of electrolytes normally present in tap water commonly available in the fruit and vegetable producing districts of California, for example, has a markedly beneficial effect upon the surface tension depressing power of the wetting agent. For example, pure water containing 0.02% of "Aerosol OT" having a surface tension of 38.9 dynes per centimeter at 77° F. (S. T. of pure water measured in same manner and under same conditions is about 72.0), shows a surface tension of only 26.3 dynes per centimeter after 0.25% by weight of ordinary salt (NaCl) has been dissolved in it.

Generally speaking, for the attainment of consistently satisfactory results when practicing the present process with the aid of a synthetic organic surface active agent, it is desirable that the application of the surface tension depressant to the wet fruit or vegetables to be dried shall be so accomplished that the surface tension of the resultant liquid mixture of water and depressant formed on the surface shall not exceed about 35 dynes per centimeter, although the benefits of the invention can be realized to some extent where the surface tension of such mixture is higher. In the best mode of practicing the invention, however, it is usually desirable that such surface tension be kept lower than 30 dynes per centimeter when employing a synthetic surface tension depressant, this being especially so in the case of tomatoes and certain other products having skin characteristics such that it is difficult or impossible to wet their skin uniformly with an aqueous liquid having a surface tension substantially greater than 30 dynes per centimeter.

In the specific illustrative example hereinabove given, wherein washed and rinsed tomatoes are to be dried in accordance with the present invention, the surface active or conditioning agent applied to the wet fruit by spray nozzles or atomizing heads 38 is a tap water solution of "Aerosol OT," which is at such concentration and is sprayed from the nozzles at such a rate that the resultant aqueous mixture formed on the treated wet tomatoes has a surface tension averaging below 30 dynes and most desirably approximating that of a tap water solution containing 0.025% of the actual surface active compound. When using this particular depressor compound, it is usually inadvisable to aim at any lower concentration than this for such resultant or final aque-

ous mixture; because at concentrations of "Aerosol OT" materially lower than 0.025%, even though the surface tension may still be well below 35 dynes per centimeter, the wetting power of the mixture, i. e. its power to film out very thinly and uniformly over the surface of the article, is less than is desirable for practical purposes. In other words, there is no simple direct relation between the surface tension of the mixture and its ability to spread out over the article in the manner desired in the present process. Staying within an approximate concentration range of from 0.03% to 0.1% (i. e. in the final mixture, on the article, of residual adhering water and the applied surface-conditioning solution or liquid) has been found desirable in practice when using "Aerosol OT," and is a good working rule.

The proper volume of conditioning solution of given higher concentration to discharge from nozzles **38** per unit of time in order to obtain the predetermined lower concentration of surface conditioner in the aforesaid final aqueous mixture on the fruit, can be determined with sufficient accuracy, in any given instance, from a consideration of the observable operating data of the apparatus installation to be employed. Thus, in the normal operation of a tomato handling installation such as that here illustrated, the maximum quantity of fruit carried under the nozzles **38** by the rinse conveyer **21** per minute will be in the neighborhood of 750 pounds (45,000 pounds per hour); and it is a simple matter to determine by actual test approximately how much rinse water remains on that amount of fruit entering the surface conditioning hood **40** each minute. From this data, assuming any convenient concentration for the conditioning solution to be applied, the proper constant rate of discharge from the nozzles necessary to produce the desired final concentration on the surface of all fruit traveling under them is readily calculated with sufficient accuracy, assuming full capacity operation at all times. Although such handling apparatus seldom operates continuously at full capacity in usual packing house practice, operation being sometimes temporarily at as little as 50% capacity or less for variable periods as already explained hereinabove, it is usually impractical to attempt to vary the supply of surface conditioning material in accordance with such variable flow of fruit through the conditioning hood. Accordingly, for practical purposes, it is generally best to maintain the rate of discharge of conditioning material fixed or constant on the basis of assumed full capacity operation. However, provision should be made for adjusting such rate to get optimum results on the basis of observed performance.

In the present illustrative example, which is typical of good practice, the arrangement and operation are such that the volume of conditioning solution issuing from nozzles **38** in the conditioning hood **40** and actually applied to the articles (tomatoes) passing therethrough is intended to be approximately equal to the volume of rinse water still clinging to the tomatoes when they enter said hood. Therefore, assuming that it is desired to reduce the resultant liquid mixture on the surface of the tomatoes to that of a 0.025% tap water solution of "Aerosol OT," this can be done by applying to the tomatoes an amount of a 0.05% "Aerosol OT" solution equal to the amount of rinse water that is on the rinsed fruit. This result is sufficiently approximated in the present example by spraying a 0.05% tap water solution of "Aerosol OT" through nozzles **38** at a constant rate of 10 gallons per hour, or slightly more than one-half of 1% of the volume of fresh water rinse applied in rinsing hood **23**. Under average conditions typically prevailing in a tomato packing plant, this gives a surface tension of around 28 dynes per centimeter for the aforesaid final liquid mixture on the fruit and the resultant drip therefrom.

In typical desirable practical embodiments of the novel process, proper application of the surface conditioning agent to wet articles in the manner described herein results in such a pronounced run-off or streaming of liquid therefrom that the liquid adhering thereto is quickly reduced to a residue often amounting to not more than 25% or an even lower proportion of the quantity of water which adhered to the articles just prior to said application. Such residue, moreover, is distributed over the surface of the articles in a film so thin as greatly to expedite its subsequent removal through evaporation either spontaneously or by any suitable method of promoting evaporation of sensible surface moisture.

Since pure di-octyl sodium sulphosuccinate is somewhat difficult to dissolve quickly in water, it is usually more convenient, in making up the surface conditioning solution for use in the present process, to employ one of the less concentrated forms of this compound that are commercially available, such as "Aerosol OT Aqueous 25%" which, as its name indicates, contains 25 parts by weight of "Aerosol OT" 100% and 75 parts by weight of water. This material is also sometimes known under the commercial designation or trade name "Vatsol" (i. e. "Vatsol OT").

Because surface tension varies with temperature, becoming higher as the temperature of the liquid decreases, it is of course necessary to take this factor into account in determining the proper concentration of the conditioning liquid that is to be atomized upon the fruit. In the foregoing specific example, it is assumed that the operating temperature, i. e. temperature of the mixture of adherent rinse water and applied conditioning solution, approximates 70° F. If the operating temperature is lower than 70°, a concentration of "Aerosol OT" in the conditioning solution or liquid sprayed from nozzles **38** that is somewhat higher than 0.05%, such as 0.075% for example, is advisable in order to give the resultant aqueous mixture formed on the surfaces of the fruit the desired good filming-out properties. Other practical operating conditions may, in any given instance, render advisable the use of such higher concentrations, or the application of lower concentrations at a greater volume rate, in order to obtain good filming out. A packing house operator of average skill can readily tell, by observing this matter of filming on the fruit or vegetable surface, whether the method is operating satisfactorily, and adjust the rate of application (e. g.) if necessary.

Subject to the limitation that the concentration of conditioning agent in such liquid mixture must not be lowered beyond that which is essential to cause proper filming of moisture over the surface of the fruit and prevent re-coalescence of such moisture into discrete adherent globules, the lower the concentration of "Aerosol OT" or "Vatsol" in said liquid mixture, the better. If too large an excess of the conditioning agent is used, it is possible to impede drying preceptibly probably because, as the water film dries down, the "Vatsol" or "Aerosol OT" concentrates to a viscous state that dries slowly. Thus, not only is it

more economical to use conditioner solutions of as low concentration as will work well under practical operating conditions, but this also tends to result in more expeditious and effective drying than where an unnecessarily large amount of conditioning agent is applied. Without implying any rigidly fixed upper limit of concentration, it may nevertheless be stated generally that it is ordinarily undesirable, practically speaking, for the concentration of "Vatsol" in the liquid mixture on the fruit resulting from the treatment in the conditioning hood 40 to be higher than about 0.5% as a maximum; and in what is now regarded as the best mode of practicing the invention, such concentration is most desirably between 0.03% and 0.10%.

In order that the relatively small amount of conditioning liquid material required to give such low concentrations may be discharged into the conditioning hood 40 in a manner most likely to ensure reasonably uniform application of said material to the surfaces of all the articles which compose the stream of fruit traveling through said conditioning hood and which are being turned over and over by the revolving rolls of conveyor 21, it is advisable to employ a special type of nozzle 38 which will atomize the surface conditioning or surface tension depressant solution into virtually a mist or fog and direct it upon the sub-adjacent fruit in this form. One excellent type of nozzle for this purpose is that marketed as the "Monarch" spray nozzle by Monarch Manufacturing Works Inc., Philadelphia, Pennsylvania, and disclosed in U. S. patent to Murphy 1,982,228. In such an installation as that illustrated in the accompanying drawings, wherein the conveyor 21 is assumed to be about 4½ feet wide, four No. 350 Monarch nozzles type F80 are satisfactory to use, each adapted to deliver about 2.5 gallons of solution per hour when supplied with solution by pump 43 under a constant pressure of 80 pounds. A nozzle of this type produces a solid cone of fine spray or mist, the base diameter of which is approximately equal to the altitude of the cone, and the spray angle being about 80°. Locating four nozzles 38 of this type about 14 to 15 inches above the elevator 21 and spacing them an equal distance apart transversely thereof, gives a slight overlap of the spray cone bases and ensures adequate coverage of all the fruit in the traveling stream as it passes through hood 40. Employing such equipment, a substantially uniform small quantity of the surface conditioning solution can be applied to each fruit, this quantity being comparable in a general way, as regards order of magnitude, to the quantity of water adhering to the fruit as it enters the spraying zone.

In drying other fruits or vegetables with the aid of the present process, where it is desired to make use of an existing drying installation, the procedure may be substantially as described hereinabove for tomatoes, with such minor changes in mechanical handling as may be usually customary in the commercial packing of the particular other fruit or vegetable concerned. However, it is in some cases desirable to use a higher concentration of the conditioning agent, not necessarily to obtain a different surface tension but rather to obtain a better wetting and filming action, which latter, as has already been indicated hereinabove, does not depend solely upon reduction of surface tension. In applying the new process to drying wet lemons for example, it is found that for best commercial results it is generally desirable that the concentration of "Aerosol OT" in the liquid mixture resulting from application of the conditioning spray or mist to the wet fruit should usually not be lower than approximately 0.03%. Even at this concentration, the solution does not wet as well as might be desired; but the conditioned lemons dry almost twice as fast as unconditioned lemons handled in otherwise the same way. Using an "Aerosol" concentration of 0.06% in the surface-conditioning solution applied, the solution wets lemons well. In a typical instance, the lemons dry in 6 minutes when exposed to still air at 75° F., as against 42 minutes for untreated lemons.

In the case of freshly washed and rinsed oranges, an "Aerosol" concentration of 0.025% in the final liquid mixture on the fruit surface—the same as in treating tomatoes—films the adherent water out over the fruit very well and cuts the time of drying down so much that the length of the drying installation ordinarily required in the typical orange packing house can in most cases be reduced at least one-half and sometimes as much as two-thirds, thus enabling drastic reduction in installation and operating costs. Actual operation of the novel process under regular commercial conditions has in some instances shown that, when drying oranges under reasonably favorable conditions, the drier unit proper may even be eliminated entirely, thus enabling the packer to cut down still farther his machinery investment and operational costs. This is especially feasible where, after being subjected to the conditioning mist or spray, the fruit is passed to a water eliminator of the rotary cylindrical brush type in which the fruit is wiped by the brushes, thorough and uniform distribution of the surface active agent contained in any residual liquid mixture still clinging to the fruit being thereby effectively accomplished. Under such circumstances evaporation of the resultant extremely thin moisture film adhering to the fruit surfaces and to the brush bristles, simply by exposure to air even at ordinary room temperature and without the aid of special air circulating means, may occur completely and with great rapidity.

As illustrative of many other synthetic surface tension depressants that can be satisfactorily employed in practicing the invention, mention may be made of the following by way of example:

"Intramine Y," a product of Synthetic Chemicals Inc., of Jersey City, New Jersey; said to be the sodium salt of sulphonated lauryl and myristyl collamide.

"Intramine WK"—similar to Intramine Y.

"Nacconol Y Extra," a product of National Aniline & Chemical Co., (Allied Chemical and Dye Corporation) of New York, N. Y.; said to be a sodium alkyl aryl sulphonate.

"Gardinol," also known as "Duponol," a product of E. I. du Pont de Nemours & Co., Wilmington, Delaware; said to be sodium sulphate of technical lauryl alcohol.

"Lupomin W–E," a product of Jacques Wolf and Co., of Passaic, New Jersey; said to be a fatty acid ester.

"Nopco DLN," a product of National Oil Products Co., of Harrison, New Jersey; said to be an aliphatic sulphonate.

"Nopco 1067," also a National Oil product; said to be an alkyl aromatic sulphonate.

"Aresket," a product of Monsanto Chemical Company, Rubber Service Laboratory Division,

Akron, Ohio; said to be monobutyl diphenyl sodium monosulphonate.

"Santomerse," also a Monsanto product; said to be an alkylated aryl sulphonate.

"Tergitol," a product of Carbide and Carbon Chemical Corporation, New York, N. Y.; said to be a higher secondary alcohol sulphate.

As typical of how the above mentioned surface tension depressors may be employed effectively in carrying out the present process, suitable concentration ranges for several of them, with reference to the conditioning solution or dispersion as applied to wet articles which have been allowed to drain for a few seconds are given, as follows: "Gardinol WA," 0.12% to 1.0%, at 70° F.; "Nopco 1067," 0.12% to 1.0% at 70° F.; "Nopco DLN," 0.5% to 2.0% of commercial solution at 70° F.; and "Intramine Y," 0.25% to 1.0% at 70° F.

It may also be pointed out that, since temperature plays a very important part in the activity of surface active materials, it is feasible, and sometimes desirable, to take advantage of this fact, in practicing the present invention, by warming the fresh water rinse (if used) to a point where it will maintain, lower or elevate the skin or surface temperature of the articles to be dried, in order to achieve the most practical results from succeeding application of surface active agent. It is not practical to warm the conditioning surface solution itself when this is applied almost as a fog by high pressure sprays, because such fine atomizing would cool the material to air temperature before it strikes the articles. But if the surface of the article is warm, this will quickly raise the temperature of the small quantity of applied surface active material, thus increasing its activity and decreasing the amount necessary to use at a lower temperature. Therefore, where practical operating conditions permit, it is of great advantage to have the surface or skin temperature of the wet articles at from about 80° to 100° F., when the conditioning solution is applied thereto, and conduct of the process under such conditions is an especially desirable embodiment of the invention.

The employment of a water-soluble synthetic compound having powerful surface tension reducing action has been more particularly referred to hereinabove, by way of example, in explaining the underlying principles of the invention. Moreover, such synthetic agents are at present regarded as constituting a class of surface active agents which, in general, are most desirable to employ in commercially practicing the novel process. For one thing, the composition and purity of most of them, as supplied by the manufacturers, is usually dependably constant, thus assuring reasonably consistent performance. Also, their potency as surface tension depressors is ordinarily so high that they are effective at relatively very low concentration and hence only a minute deposit thereof is left on the surface-dried articles. It is to be understood, however, that the invention is in no sense limited to the employment of synthetic surface active agents. On the contrary, use may be made of any of a wide variety of other surface active substances of quite different chemical classification and character. Provided the surface active or conditioning agent employed is not injurious to the fruit, vegetable or other article under the conditions of use, is permissible to use under governmental regulations, and is not too costly to be practical, any of the large number of surface tension depressors which are already known, or any which may hereinafter be discovered, may be used in practicing the invention, broadly considered, provided such depressor is effective, when applied to the wet fruit or vegetable in accordance with the invention, to thinly film adherent moisture out over the fruit or vegetable surface and prevent its standing thereon in droplets.

Generally speaking, surface tension depressants of the sulphonated oil type, such as sulphonated castor oil, are among the less desirable surface tension depressants to employ in practicing the present invention. This is because such surface active agents usually penetrate the rind of fruit quite readily and enter into the cells of the skin tissue of oranges, grapefruit and lemons, for example, to such an extent as to tend to cause the fruit to shrivel or wither abnormally fast after it is packed and shipped to market. Moreover, this undesirable effect is not entirely overcome by waxing the fruit after it has been surface dried. Besides, most sulphonated oils have relatively low potency in depressing the surface tension of water as compared to various other available surface active agents.

Under some circumstances it is possible to utilize alkali metal or other soaps of fatty acids as surface tension depressants in accordance with the principles of the invention herein disclosed, and while the use of such soaps for that purpose is generally not so desirable as is the use of a synthetic depressor such as an "Aerosol" wetting agent, for example, it does enable the benefits of the invention to be realized to a degree that is often substantial and in some cases quite satisfactory. Such soaps have the disadvantage of being decomposed when used in hard waters containing calcium and magnesium salts and forming the substantially insoluble fatty acid salts of calcium and magnesium. This may render their use in the practice of the present invention quite impractical in a fruit packing locality (e. g.) where the available water supply is very hard. Aside from this, however, most such soaps are not as powerful surface tension depressors as "Aerosol OT," for example, and hence must be used in larger quantity. Soaps also tend to leave a grayish film on the dry fruit, which is detrimental, although this can be removed by brushing the dry fruit.

Among soaps which may be used as surface tension depressors in practicing the present process, cold process cocoanut oil soaps are especially suitable since aqueous solutions of them in reasonably small concentrations have a low surface tension and, in addition, they exhibit considerable resistance to decomposition in hard water. For instance, a 0.25% solution of cocoanut oil soap (16 parts of caustic soda to 84 parts of oil by weight) has a surface tension of about 25 dynes per centimeter at 73° F., and good filming properties; while a 0.5% solution has a surface tension of about 27 dynes at a temperature range of 75°–78° F. The rather surprising fact that such a low surface tension is obtained at 73° F. renders the use of this soap of particular advantage, if a soap is to be employed as the surface active agent, where a fruit packing housing does not heat the wash water and uses little or no treating chemical therein. Other soaps usable in the process are sodium oleate and triethanolamine oleate, a 0.25% water solution of the former having a surface tension of around 28 dynes per centimeter at 73° F., and a 0.25% solution of the latter having a surface tension of around 29 dynes per centimeter at 75° F. The sodium

salt of sulphonated oleic acid, although not classed as an ordinary soap, is another surface tension depressant which can sometimes be used to advantage.

It is also possible within the broad scope of the invention to employ various other types of surface tension depressants in accordance with the principles of the invention herein disclosed. Generally speaking, however, many of such other surface active agents do not lend themselves well to application by atomizing or misting upon the wet fruit, but have to be applied by some other method less simple and more difficult to control in actual practice. For this reason, aside from other considerations, the use of such other types of surface tension depressants in practicing the invention lacks some of the important practical advantages afforded by the use of "Aerosol OT" or similar synthetic surface active agent. Casein, for example, may be employed as the surface active agent within the broad scope of the invention. Thus, a technical grade of casein may be dissolved in a soda ash solution, in proportion of 10 grams of casein and 2 grams of soda ash, and the solution allowed to age for 36 hours. Solutions thus prepared and containing 0.1%, 0.5% and 1.0% of casein have surface tensions at 80° F. approximating 45, 48 and 46 dynes per centimeter, respectively. Applied to wet oranges in accordance with the invention in concentrations of from 0.06% to 0.25% such as a casein-soda ash solution expedites drying of the wet fruit materially. However, the solution develops considerable odor in a relatively short time and use of this material in a packing house under practical operating conditions would be attended with certain difficulties and disadvantages due to the inherent nature of such material.

It is accordingly evident that the best type of surface active agent to employ in practicing the present process is one which has the desired degree of surface tension reducing activity at minute concentrations, ensuring that a minimum of residue will remain on the fruit or other articles after surface drying, and on the machinery and equipment by which the articles are handled after said agent has been applied to them. Moreover, such residue should most desirably be transparent, non-tacky and non-hygroscopic; should not bloom, undergo chemical change, or putrefy after application to the fruit or vegetable that is to be surface dried. The larger the residue of surface tension depressor left on the surface dried fruit, the greater is the tendency to give the skin of the fruit a sticky, gummy feel and to render it hygroscopic.

In some cases, it is feasible to apply the small-volume conditioning spray directly to washed fruit that has not been rinsed with fresh water as in the specific example hereinabove described. Under this head, there are two cases to be considered:

The first case is where fruit is delivered to the packing house comparatively free from dirt, scale, etc., and requires only washing, (e. g.) in a soaking tank, with plain and often unheated water in order to cleanse it sufficiently. In this case, the fruit, after being removed from the soaking tank, may be subjected directly to the conditioning spray or mist of 0.05% tap water solution of "Aerosol OT," for example, whereupon the ensuing rapid draining off (or "run-off") of adhering wash water is so complete that such small deposit of solid matter as may be left on the completely surface-dried fruit is too slight

to be discernible or to materially dull the bright clean appearance of its surface. This result becomes possible to achieve, despite the fact that the conditioning liquid is sprayed or misted upon the fruit at the rate of only 10 gallons per hour (e. g.) as before, because of the action of the surface tension depressor in effecting such prompt and nearly complete drainage from the fruit (or vegetable) of all adherent wash water together with the relatively small amount of solid matter carried thereby. Application of the invention in this particular manner may thus effect a very large saving in fresh water formerly required for rinsing in the usual way, in addition to accomplishing the surface drying of the fruit much more expeditiously and completely.

The second case to consider, where the usual fresh water rinse is to be omitted, is where the wash water clinging to the fruit or vegetables after they are removed from the washing tank is relatively dirty and contains a detergent of some kind or where either separately or in addition, such wash water contains a decay preventive or inhibitor such as borax, for example. In such case, application of the conditioning liquid as a spray or mist at such a low rate of 10 gallons per hour would ordinarily not suffice to prevent a deposit or residue of solid matter from being left on the fruit after complete surface drying in amount great enough to objectionably affect its appearance and also to interfere with subsequent application of a suitable waxy protective coating. However, where the quantity of such foreign matter carried by the adherent wash water is not excessive, the usual fresh water rinse may even in this case be wholly or partly dispensed with by proper application of the principles of the present invention. For instance, if the fresh water rinse is to be omitted entirely, a suitable procedure within the invention is to apply the conditioning solution to the washed fruit, after it has been removed from the soaking tank, in successive portions each of lower surface conditioner concentration than where only one application is made, the successive applications being spaced apart slightly. Thus, with the valve in the line supplying rinse pipe 22 closed, the first application of conditioning solution may be of a 0.03% tap water solution of "Aerosol OT" supplied at the rate of 10 gallons per hour through nozzles 38. Then, after allowing a brief interval of time (e. g. a few seconds) to elapse in order that accelerated drainage or liquid run-off from the fruit may occur sufficiently, there follows a second application of the same concentration of conditioning solution at the same rate, supplied through nozzles 46. This procedure involves a slightly greater total expenditure of surface active agent than does the procedure first described. Also it requires using twice as much water in applying the conditioning agent, but the increase is only a small fraction of what is required by the usual fresh water rinse which is omitted. Therefore, where the water supply is limited and a substantial saving in the amount of water used in the packing house is accordingly an important objective—as is not infrequently the case—this modified form of applying the novel process offers distinct advantages for this reason, not to mention the marked improvement it affords in the surface drying of fruits and vegetables in respect to both rapidity and completeness.

Omitting the customary fresh water rinse on fruit or vegetables that have been washed with the

aid of soap or soapy detergents, and applying the surface conditioning liquid directly to the wet fruit as it comes from such washing, has the further advantage that the wash water clinging to the articles already has a lower surface tension than plain water, and ordinarily will also be less in quantity, than the fresh water which would replace it. Therefore, where circumstances render it practical to dispense with the fresh water rinse, this further advantage of doing so has great practical importance in considerably reducing the amount of surface active agent necessary to ure in carrying out the present process.

Again, instead of omitting the fresh water rinse altogether, it is sometimes desirable to cut it down to a half or a third, say, of its normal amount, thereby rinsing off the greater or a considerable part of the dirty wash water; then following with a single application of conditioning agent at full strength or concentration, or with two or more successive applications at part strength.

In still another practical embodiment of the invention, a water soluble decay preventive or inhibitor, such as borax or thiourea, for example, may advantageously be incorporated directly in the surface conditioning or depressor solution, especially where the conditioning agent is of a type such that its surface tension reducing action or potency is actually enhanced by the presence of an electrolyte (or other compound) or, at least, is not adversely affected thereby. Of course, the amount of a solid decay inhibiting agent which can be thus added to the surface conditioning liquid is limited, practically, by the consideration that the deposit finally left on the surface dried fruit or vegetable must not be so great as to adversely affect its appearance or to interfere with subsequent application of a satisfactory protective waxy coating. Subject to this limitation, however, this expedient can be resorted to at times with considerable advantage; especially since it is possible in this manner to so exactly control the amount of the decay inhibiting agent that remains on the fruit after it has been surface dried and continues to safeguard the fruit by continued decay-inhibiting action.

In the foregoing description of certain specific ways of practicing the invention, reference has been made more particularly to application of the surface conditioning solution or dispersion as a mist or fog atomized from high pressure nozzles, because this is at present deemed to be the most effective and readily controllable method of application. It is to be understood, nevertheless, that the invention is in no sense limited to mechanical details of this kind, and that application of the conditioning solution to the wet articles by any other suitable method is permissible within the scope of the invention. For instance, the misting or atomizing heads 38 by which the conditioning solution is applied to the wet fruit in the apparatus system here illustrated, could be replaced by ordinary spray nozzles or by means for simply dripping the solution upon the traveling stream of articles below; and the subadjacent section of the roller conveyer 21 by revolving brush mechanism such as that shown at 27, 28. Again, a special dip tank containing conditioning solution, through which tank the wet and at least partially drained articles would be passed after rinsing and which would be provided with means for automatically adding more concentrated conditioning solution to make up for the dilution due to water carried in by in-coming articles, thus maintaining substantially constant the concentration of the active surface conditioning agent, could replace said atomizing heads or nozzles 38. But either of these methods of application would require more skilled attention on the part of packing house operators than the atomizing or misting method which has been described hereinabove and which is regarded as most desirable in actual practice.

Likewise, broadly considered, the invention is not limited to employment of any particular drying procedure or equipment following application of the surface conditioning agent to the articles to be dried; or, indeed, to the use of any drying equipment whatever, since the residue of water left on the articles after proper application of such agent may often then be so slight and filmed out so extremely thin that merely exposing the articles to the evaporative action of the unheated surrounding atmosphere for a brief period, without subjecting them to special further handling or treatment, suffices to complete the desired surface drying thereof satisfactorily. However, in order that the effect of the applied surface active agent in causing quick run-off of excess water from the wet articles and fast drying of the persisting residue may be realized in maximum degree, prompt spreading of the conditioning liquid containing said agent over the surface of the articles by means of soft cylindrical brushes or the like, simultaneously with or immediately following application to said articles, is commonly advisable as has already been pointed out, and this is accordingly a feature of the new process in its best practical embodiments.

Notwithstanding the fact that it is most desirable, in practicing the new process, that the surface conditioning liquid containing the surface conditioner or surface active agent shall be so applied as to cause the filming-out of residual liquid to be complete or uniform over the entire surface of the wet articles treated, such completeness or uniformity is not indispensable to a realization of the benefits of the invention in a degree that is marked and sufficient to be of substantial practical importance. It is found that even where the filming-out seems to be only partial, and hence not uniform over the whole article surface, surface-drying of the article occurs much more rapidly than it does under conditions identical except for application of the surface conditioner as herein disclosed. Thus, despite the fact that it is generally better, when employing a synthetic surface conditioner, to apply to the wet articles in such manner that the final liquid mixture on their surfaces shall have a surface tension below 30 dynes per centimeter in order to facilitate complete filming, greatly accelerated drying is still obtainable at surface tensions up to about 35 dynes per centimeter, such acceleration falling off rapidly, however, above this point. In the case of some protein surface conditioners on the other hand, such as the casein-soda ash solution hereinabove referred to, good filming and accelerated drying occur with surface tensions as high as from 45 to 50 dynes per centimeter, even though the filming-out of residual liquid is not necessarily complete. The appended claims are therefore to be construed in a correspondingly broad sense except when otherwise expressly indicated.

In order to approximate most nearly complete or uniform filming of residual liquid over the entire surface of the articles undergoing treat-

ment, the best procedure is to permit the wet articles to roll or mill about as they are advanced by suitable conveyer means toward the surface conditioning zone where the conditioner is applied as a mist, and to have that portion of the conveyer means adjacent the surface conditioning zone consist of revolving brushes on which the articles are supported as they are advanced. The brushes act to remove any loosely adhering drops of water before the articles enter the conditioning zone and, during travel of the articles through the conditioning zone, to thoroughly mix the applied conditioning solution with the residual water still clinging to the articles. The continued wiping action of the brush rolls upon the articles after they have left the conditioning zone facilitates the draining or run-off of liquid resulting from the surface tension reduction and otherwise aids in completing the mechanical "elimination" of aqueous liquid from the surface of the articles.

Another unexpected advantage accruing from the present invention is that in the case of certain fruits and vegetables, notably tomatoes, application of a surface conditioner for removal of surface moisture in the novel manner described has a definitely perceptible effect, in and of itself, in reducing the rate of withering or shrinkage which such commodities normally undergo in the course of being shipped to marketing centers and being distributed to consumers. Where application of the conditioner has this effect, it supplements that of any waxing treatment that may be subsequently applied to the surface dried fruits or vegetables; and if the latter treatment is normally designed to give the maximum degree of shrinkage control considered advisable, it may be well in such cases to modify it by lessening the amount of wax applied. Thus, observations made in the course of removing surface moisture from tomatoes by the process of the present invention using "Aerosol OT" as the surface conditioner, show a resultant shrinkage control amounting to from 2% to 10% of that ordinarily obtained in commercial practice by use of the waxing process disclosed in the Brogden and Trowbridge Patent 1,940,530. With citrus fruits, on the other hand, only very little if any shrinkage control appears to be attributable to the new process. Moreover, as has been pointed out already hereinabove, the use of surface conditioners such as sulphonated oils tends to increase shrinkage, and this is true to even a greater extent with most soaps.

Although the most important present use of the herein described process is in connection with the surface drying of wet fruits and vegetables in preparing them for market, the process in its broader aspects is applicable to the surface drying of wet articles generally which can be advantageously dried in a similar manner, especially such as are likely to be injured by exposure to high drying temperatures; and the process is believed to be novel in this broader aspect also. As illustrating other uses of the novel process than in the removal of surface moisture from fruits and vegetables, mention may be made of its application to the drying of containers filled with heat sensitive materials preparatory to packing and storage or shipment, specifically in the drying of wet cans containing citrus juices before the cans are placed in cartons and stored. Since the tin plate of which such cans are made is not always of the highest quality, it is generally rather heavily oiled in order to prevent pinhole rust during transit and storage of the empty can. After the cans are filled with hot juice and sealed, they are cooled as rapidly as possible by means of a water bath or water sprays, the can temperature generally being reduced to around 110°–120° F. The cans are then placed in cartons and stored, any adhering droplets of water being expected to evaporate due to the residual heat of the can. Often they do not however, or do so only incompletely, with the result that there is considerable spoilage of such canned goods due to pinhole rust from incomplete removal of moisture from the can exteriors. It has been found that such removal can be effected very quickly and completely by subjecting the wet cans to the process of the present invention, applying a 0.075% "Aerosol OT" solution thereto by misting or otherwise. The use of a somewhat more chemically inert conditioner, such as sodium lauryl sulphate (e. g. "Gardinol WA"), instead of "Aerosol" affords some advantage in the way of excluding any possibility of corrosive action of the conditioner upon the iron of the tin plate.

The employment of synthetic surface tension depressant compounds in hastening the surface drying of wet articles generally, and of fresh fruits and vegetables in particular, regardless of the specific manner and details of application for this purpose, is believed to represent an important and broadly novel advance in the art of surface drying articles.

In whatever manner the liquid medium containing the surface conditioner in low concentration of the order hereinabove disclosed is applied to wet articles in practicing the novel process, it is virtually never necessary to apply said liquid medium in quantity greater than is equivalent to that received by articles traveling in single layer at a speed of around 25 to 30 feet per minute in a path 4½ feet wide under atomizing or spray means which discharge said liquid medium down across the entire width of said path at a constant rate of 50 gallons per hour; and reference in the appended claims to applying a "small" quantity or amount of the surface conditioning liquid to wet articles is to be understood as signifying application in quantity not substantially exceeding the equivalent thus defined. In the best practical embodiments of the invention, the quantity applied is equivalent to an application rate within the range of 10 to 30 gallons per hour, with rates as low as 10 gallons per hour or thereabouts being commonly feasible and most desirable. It is to be understood that the stated rates represent the total quantity of liquid conditioning medium employed in continuous operation, whether it be applied in a single application or in two or more successive applications.

What is claimed is:

1. In the preparation of fresh fruit and vegetable articles for market by cleansing them with the aid of water applied in relatively large volume in a cleansing zone, and thereafter surface-drying them, the process which comprises moving the wet articles out of the cleansing zone and, while supporting them in such manner as to permit liquid to drain therefrom, applying to them a relatively small volume of a water-miscible surface-conditioning liquid containing a surface active agent in concentration, not substantially exceeding 2%, effective to promote filming-out and accelerated run-off of the adhering water to an extent such that the amount left on said articles is substantially less than the amount

which said articles carried immediately prior to such application; the volume of the surface-conditioning liquid thus applied being so controlled that the amount of surface active agent actually employed for a given quantity of said articles is restricted to only a small percentage, not substantially exceeding 3%, of what would have to be employed in order to obtain the same run-off effect, if contained in the large volume of water applied in said cleansing zone.

2. The process set forth in claim 1, wherein said articles, while supported as stated, are subjected to a brushing action to expedite mixing of the applied surface-conditioning liquid with the water adhering to the articles.

3. The process set forth in claim 1, wherein said surface active agent is a water soluble synthetic surface tension depressant in low concentration not substantially exceeding 1% said depressant being selected from the group consisting of sulphodicarboxylic acids and compounds thereof, and the quantity of liquid applied to each article being comparable in order of magnitude to the quantity of water initially adhering thereto.

4. The process set forth in claim 1, wherein said surface active agent is a water-soluble substance comprising liquid containing a high molecular alcohol ester of sulphosuccinic acid in concentration, not substantially exceeding 1.0%, the quantity of liquid applied to each article being comparable in order of magnitude to the quantity of water initially adhering thereto.

5. The process set forth in claim 1, wherein said surface active agent is a water-soluble di-octyl sulphosuccinate in concentration, not substantially exceeding 1.0%, the quantity of liquid applied to each article being comparable in order of magnitude to the quantity of water initially adhering thereto.

6. The process set forth in claim 1, wherein said surface-conditioning liquid is finely sprayed upon the wet articles, while they are supported to permit drainage of liquid therefrom, in such manner that the quantity applied to any article is generally comparable in order of magnitude to the quantity of water carried by said article immediately before such application.

7. The process set forth in claim 1, wherein the cleansing of said articles includes a final rinsing with a relatively large volume of fresh water, and wherein the surface tension depressant liquid is finely sprayed upon the wet articles, while they are supported to permit drainage of liquid therefrom, at a rate such that the quantity applied to any article is generally comparable in order of magnitude to the quantity of water carried by said article immediately before such application.

8. The process set forth in claim 1, wherein the surfaces of said wet articles are moderately warm when said liquid medium is applied.

9. The process set forth in claim 1, which further includes applying to the surface-dried articles a protective coating material in non-aqueous condition.

10. The process set forth in claim 1, which further includes applying to the surface-dried articles a coating material dissolved in a non-aqueous solvent.

11. The process set forth in claim 1, which further includes applying to the surface-dried articles finely divided waxy material atomized from molten condition, and rubbing the articles.

12. The process set forth in claim 1, wherein the cleansing of said articles includes a final rinsing with a relatively large volume of fresh water.

13. In the art of surface-drying wet articles sensitive to high temperatures which have been subjected to previous treatment involving application of water thereto and to which water still adheres in droplets, the process which comprises applying to said articles, while supported for draining, a relatively small quantity of water, generally comparable in amount to that adhering to the surface of the articles, containing a small percentage, not substantially exceeding 2% of a surface tension depressant, and sufficient to give the resultant liquid mixture on the surface of said articles a surface tension not higher than 35 dynes per centimeter, and subsequently exposing the articles to a drying atmosphere.

14. The process of removing surface moisture from wet articles that are sensitive to high temperatures, which includes the step of atomizing upon such wet articles, while they are supported for draining, a small quantity of a low-concentration water solution of a water soluble synthetic organic compound having pronounced surface tension reducing action, the quantity of said solution applied to each article being generally comparable in order of magnitude to the quantity of water initially adhering thereto, and the concentration of said solution not substantially exceeding 2% but sufficient to ensure that the surface tension of the resultant liquid mixture on said articles shall not exceed 50 dynes per centimeter.

15. The process of removing surface moisture from fresh fruits and vegetables carrying adherent water, which includes the step of applying to the wet articles, while supported for draining a water solution of a di-octyl sulphosuccinate of an alkali metal at such concentration, not substantially exceeding 1.0% and in such amount that the concentration in the resultant liquid mixture on the articles is from about 0.03% to about 0.1%.

16. The process of removing surface moisture from wet articles that are sensitive to high temperatures, which includes the step of applying to such wet articles at relatively low temperature, while they are supported for draining, a water solution of a di-octyl sulphosuccinate of an alkali metal in such concentration, not substantially exceeding 1.0% and quantity that the concentration in the resultant liquid mixture on the articles is from about 0.03% to about 0.1%.

17. In the surface treatment of articles sensitive to high temperatures by a procedure which includes contacting the articles with an aqueous liquid in relatively large volume, then discontinuing such contacting and thereafter surface-drying the articles, the process which comprises supporting the wet articles after such discontinuance and in such manner as to permit liquid to drain therefrom, and applying to said wet articles so supported a predetermined small volume of a water-miscible surface-conditioning liquid medium containing a surface active agent in concentration, not substantially exceeding 2%, effective to promote filming-out and accelerated run-off of the aqueous liquid adhering to said articles; the volume of the surface-conditioning liquid thus applied being so controlled that the amount of surface active agent actually employed for a given quantity of said articles is restricted to only a small percentage, not substantially exceeding 3%, of what would have to be employed, in order to produce the same run-off effect, if contained in the aforesaid large volume of aqueous liquid with which the articles were previously contacted, and being sufficient to ensure that the surface

tension of the resultant liquid mixture on said articles does not substantially exceed 50 dynes per centimeter.

18. The process set forth in claim 17, wherein said liquid medium is finely sprayed upon the wet articles in such manner that the quantity applied to any one article is generally comparable in order of magnitude to the quantity of water carried by said article immediately before such application.

19. The process set forth in claim 17, wherein the quantity of said liquid medium applied to the wet articles is equivalent to that which would be received by said articles traveling in a single layer at a speed approximately 25 to 30 feet per minute in a path 4½ feet wide under means which discharge the liquid medium in fine droplets down across the entire width of said path at a constant rate within the approximate range of from 10 to 50 gallons per hour.

20. In the surface treatment of articles sensitive to high temperatures by a procedure which includes contacting the articles with an aqueous liquid in relatively large volume, then discontinuing such contacting and thereafter surface-drying the articles, the process which comprises continuously advancing the wet articles, following such discontinuance in a single layer and at substantially constant speed along a predetermined path which includes a surface conditioning zone, while so supporting said articles as to permit drainage of liquid therefrom, spraying aqueous surface conditioning liquid containing a surface active agent at low concentration, not exceeding about 2% into said zone at a substantially constant rate such that each article as it advances through said zone receives a small quantity of said conditioning liquid sufficient to film out the water adhering thereto and promote further drainage of water therefrom, said quantity being such that the surface tension of the resultant liquid mixture on said articles shall not exceed about 50 dynes per centimeter.

21. The process set forth in claim 20, wherein the surface active agent is of a type capable of causing the desired filming out of water on said articles at concentrations in said liquid mixture within the approximate range of from 0.03% to 0.1%, the surface-conditioning liquid containing said agent at a higher concentration, not substantially exceeding 2%, than that desired on said articles, and being sprayed into said surface-conditioning zone at such rate that the quantity received by the wet articles produces a concentration thereon within the aforesaid approximate range; said higher concentration and said rate of spraying being so correlated that the quantity of the conditioning liquid received by said articles is substantially equivalent to the quantity which they would receive if traveling in a single layer at a speed approximating 25 to 30 feet per minute in a path 4½ feet wide under spray means discharging the conditioning liquid down across the entire width of such path at a constant rate within the approximate range of from 10 to 30 gallons per hour.

22. The process set forth in claim 20, wherein the surface active agent is a water soluble synthetic organic surface tension depressant contained in said surface-conditioning liquid at a concentration substantially below 1.0%, the surface-conditioning liquid containing said surface active agent at a concentration higher than that desired in the resultant liquid mixture on said articles and being sprayed into said surface-conditioning zone at such rate that the quantity received by the wet articles gives the resultant liquid mixture thereon the desired lower filming concentration and a surface tension not substantially exceeding 35 dynes per centimeter.

23. The process set forth in claim 20, wherein the surface active agent comprises a water soluble di-octyl sulphosuccinate, the surface conditioning liquid containing it at such concentration, substantially below 1%, and being sprayed into said surface-conditioning zone at such rate, that the resultant concentration in the resultant liquid mixture on the wet articles is within the approximate range of from 0.03% to 0.1%, and the surface tension of said mixture does not substantially exceed 30 dynes per centimeter.

24. In the preparation of fresh fruits and vegetables for market, the process wherein fresh fruit or vegetable articles are continuously advanced through a series of successive zones in a procedure which comprises washing the articles, rinsing the washed articles with fresh water to remove wash water therefrom, allowing a brief period for drainage of rinse water from the articles, then contacting them with a fine spray of a surface-conditioning liquid containing a small percentage, not exceeding about 2% of a surface active agent supplied to the surface conditioning zone at a constant rate such that each article receives a sufficient quantity to promote filming of residual water over its surface and further drainage therefrom, subjecting the articles to mechanical treatment adapted to expedite these results by prompt mixing of the applied conditioning liquid with the water on said articles, and evaporating residual sensible surface moisture from said articles.

25. The process set forth in claim 24, which further includes applying to the surface-dried articles a protective coating material in non-aqueous condition.

26. The process set forth in claim 24, wherein the volume of surface conditioning liquid supplied to the surface-conditioning zone per given quantity of said articles is only a minor fraction of the volume of water applied to that quantity of articles in the preceding step of rinsing.

27. The process set forth in claim 24, wherein the surface active agent is a water soluble synthetic organic material capable of causing the desired filming of said residual water at concentrations in said liquid mixture within the approximate range of from 0.03% to 0.1%, the surface-conditioning liquid containing said agent at a concentration substantially below 1% but higher than that desired on the articles, and being supplied to said surface-conditioning zone at such rate that the quantity received by the wet articles gives a desired lower filming concentration thereon within the approximate range aforesaid.

28. The process set forth in claim 24, wherein the surface active agent comprises an alkali metal compound of a sulphodicarboxylic acid, the concentration thereof, substantially below 1%, in the said surface-conditioning liquid and the rate at which the latter is supplied to the conditioning zone being so correlated that the quantity of the conditioning liquid received by said articles is substantially equivalent to the quantity which they would receive if traveling in a single layer at a speed approximately 25 to 30 feet per minute in a path 4½ feet wide under spray means discharging the conditioning liquid down across the entire width of such path at a constant rate within the approximate range of from 10 to 30 gallons per hour, the surface tension of the resultant liquid

mixture on the articles being not substantially in excess of 35 dynes per centimeter.

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