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PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO COMPONENT HANDLING EQUIPMENT

(71) We, USM CORPORATION, of Flemington, New Jersey, United States of America, a corporation duly organised under the laws of said State of New Jersey, Having a place of business at 426 Colt Highway, Farmington, Connecticut 06032, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improvements in or relating to component handling equipment, and more especially to mechanism for verifying component conformity to predetermined sequence. The invention is particularly adapted for relatively advancing successive elongated articles (for instance, coaxial lead type components) from a continuously operative conveyor to pass them through a processing or test station, and if qualified, to return then to the conveyor in unchanged order.

As disclosed in U.S. Letters Patent 3,669,309 and 3,971,193, for instance, large numbers of lead-bearing electronic components are predeterminedly sequenced by automatically controlled means for use in industry. In some cases the components may, when they have been arranged side by side in selected predetermined order, simply be interconnected by means of tapes for holding the components spaced for eventual sequential mounting in circuitry, and in other situations it may be that the components, when re-arranged in required order (usually in repeating, similarly-sequenced groups) will be fed seriatim for further direct processing, for example, insertion in printed circuit boards. In-line sequencers in current commercial use may have a productive capacity in excess of 18,000 components per hour.

Component manufacturers have long provided equipment for testing their products (i.e. inspection for presence and specific elec-

trical characteristics) prior to shipment to assembler's plants. The possibility of defects and damage arising during storage, in transit or in subsequent handling dictates that precaution must be taken to avoid any occasional unsatisfactory electronic component finding its way into a circuit assembly so that the latter will not also prove faulty. It has additionally been known as disclosed in U.S. Letters Patent 3,236,374, for example, to provide, in combination with an intermittently operable conveyorized machine for sequencing axial lead type components, a component testing device adapted to function each time the conveyor stopped for this purpose. The necessity to frequently stop and start such apparatus incurs a decrease in output which cumulatively may be considerable and therefore undesirable.

Additional prior art disclosures are noted in U.S. Patents 2,896,314, 3,073,446: 3,240,336; and 3,366,235.

In view of the foregoing, it is one of the various objects of the present invention to provide, in a high-speed component processing machine of the type having a stationary testing station for evaluating successive components of a series, improved mechanism for presenting each successive component to that station without interrupting continuity of operation of the machine.

Another of the various objects of the present invention is to provide an improved sequencing machine wherein electronic components are continuously fed by a normally non-stop conveyor and an associated conveyor-actuated means successively to and through a non-moving test station, the station being adapted to automatically evaluate the different components singly according to appropriate predetermined standards.

A machine for successively processing electronic co-axial lead components is hereinafter described in detail to illustrate the invention by way of example, this illustrative machine comprising a linear conveyor arranged to

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move continuously at a uniform speed and having carriers for carrying successive components in sequential spaced relation along an operating part of the conveyor. Adjacent such path of the conveyor of the illustrative machine is a stationary component test or processing station at which each component is brought momentarily to rest in the operation of the machine, which to enable the component to be removed from its carrier, tested or processed at said station or returned to the carrier again, without interrupting the uniform motion of the conveyor, also has transfer means comprising a four-bar linkage arranged to change the velocity downstream of the components relative to their carriers. Thus, in the operation of the illustrative machine, each component as it approaches the test or processing station is accelerated relative to its carrier, momentarily stopped at said station, and then returned to its carrier without stopping or retarding the continuous movement of the conveyor.

The illustrative machine also comprises means at said station for testing or verifying the electrical characteristics of the components in accordance with a predetermined programme of computer means arranged to stop the conveyor if the component is not satisfactory, thus to allow the component to be manually replaced.

The invention provides a machine for successively testing or processing electronic components or the like comprising a continuously movable conveyor for carrying the components in sequential spaced relation in individual carriers of the conveyor, a stationary component test or processing station adjacent to the operating path of the conveyor, and means for transferring successive components from their respective carriers upstream of the test or processing station and presenting them one by one at the test or processing station and then restoring them to their respective carriers, downstream from said station, said transferring means including mechanism for changing velocity of the components relative to the conveyor whereby they can be presented to said station and tested or processed there while momentarily at rest before being restored to their respective carriers on the conveyor without stopping or retarding its continuous movement during operation of the machine.

There now follows a description, to be read with reference to the accompanying drawings, of the illustrative machine aforementioned. It will be realised that this illustrative machine has been selected for description by way of example and not of limitation of the invention.

In the accompanying drawings:

Figure 1 is a view in side elevation, with portions broken of the illustrative component sequencing and taping machine having sequence testing or verifying mechanism dis-

posed along a continuously operable component conveyor.

Figure 2 is a view in side elevation and on a larger scale of portions of the verifying and component transfer mechanism shown in Figure 1.

Figure 3 is a plan view of the transfer and verifying mechanism;

Figure 4 is a view in end elevation of parts shown in Figure 3 but with portions broken away to show details of driving means for the transfer and verifier;

Figure 5 is a view similar to Figure 2 but on a larger scale to show successive positions of four-bar linkage parts of the driving means shown in Figure 4;

Figure 6 is a view similar to Figure 5 but indicating one component leaving the test station as another is about to be delivered thereto, and power connection of the conveyor drive to the transfer and verifier drives;

Figure 7 is a perspective view of the component test station and associated transfer mechanism;

Figure 8 is a view similar to Figure 7 and indicating successive positions of the components as well as an auxiliary test station; and

Figure 9 is an enlarged detail view in end elevation of a lead under test at the automatic test station.

Although the embodiment herein selected for purposes of illustration pertains to usage of the invention in a machine programmed to produce electrically tested reels of sequenced components with lead-taped spacing to match requirements of component insertion machines, it will be appreciated that application of the invention is not necessarily thus limited. The invention may, for instance, be useful in dealing with successive components which are, or are not, electrically similar, and may even have more general utility in other fields, for example, in connection with rod-like articles to be successively inspected or processed at an off-conveyor station not necessarily involving inspection of their electrical character.

The illustrative machine is one of the general type disclosed in the mentioned U.S. patent specifications 3,669,309 and 3,971,193. Thus, the illustrative machine employs a continuously operative endless conveyor of chain-type generally designated 10 (Figures 1, 2, 6 and 8) for carrying in uniformly spaced, side by side, relation a succession of co-axial lead components C to be retaped and reeled at a processing station 12 (Figure 1). It will be understood that the components C, initially fed by tapes T from their respective dispensers 14 arranged along the conveyor, are successively indexed and individually released to the conveyor according to programming means including an electronic measuring device 16 (Figure 1), for example.

As herein shown a predeterminedly selected sequence of the electronically different components C, usually in a repeat order dictated by ultimate circuit board assembly requirements, will be moved by the conveyor 10 at high speed and continuously from right to left along the upper reach of the conveyor, though the components from one or more of the dispensers 14 may be substantially identical, both physically and electrically. The conveyor 10, the dispensers, and the station 12 of the illustrative machine may be assumed for purposes of convenience to correspond substantially to the structure referred to in the specifications just referred to, it being noted that the conveyor comprises uniformly spaced, lead-engaging carriers generally designated 18 and including, respectively, a pair of leading side plates 20 and a pair of trailing pick-off plates 22. Pivotal relation of pick-off fingers or projections 24 of the plates 22 to the leading plate 20 is controlled by cam means which along the upper conveyor reach, constitutes a fixed, horizontal pair of parallel cam tracks 26 secured to the conveyor frame. It will thus be understood that upon passing from beneath delivery ends of the series of dispensers 14, each pair of upstanding fingers 24 is rapidly and continuously advancing a component C toward the station 12, but that it is highly important to ascertain, prior to re-taping or other processing at such station 12, that each component is verified as acceptable for its intended use. To this end, and at the same time to avoid any reduction in output of the continuously operative machine, an inspection or test station 28 (Figures 1, 2, 5) and component transfer mechanism 30 (Figures 2—5) is provided as will next be described.

The transfer mechanism 30 and test station 28 are located along the conveyor path upstream from the processing station 12 and downstream from the series of dispensers 14. The conveyor mechanism, as will be explained, is preferably actuated by power means (not fully shown here, but preferably including a motor, clutch-brake, and speed reducer) and a conveyor drive chain 32 (Figure 1) continuously operating the transfer mechanism in established time relationship. Notably, since the test station 28 is to determine acceptability of each component while held immobile, and output of the machine is not to be diminished (assuming the components qualified) by lowering the speed or intermittent stopping of the conveyor, the transfer mechanism 30 is adapted to change component downstream velocity relative to that of the conveyor and its pick-off fingers 24. More particularly, the transfer mechanism preferably includes a four-bar linkage (Figures 4—8) including a short crank arm 34, a longer oscillatory crank arm 36, and a connecting rod 38 for accelerating down-

stream velocity of each component C to be presented to the fixed test station 28. (The relative advance of each pair of leads L with respect to its manually propelling fingers 24 is, of course, not so great as to overtake or interfere with the leads and components immediately preceding in the test station 28). For this purpose a right-hand end of the connecting rod 38 is slotted at 40 (Figures 6—8) to secure thereto a cross bar formed with a pair of widthwise-spaced, lead-engaging U-shaped pickers 44, 44 respectively engageable with oppositely extending co-axial leads L, L of each component. Aligned with the cam tracks 26, 26 is a pair of stationary cam plates 46, 46 (Figures 1, 2, 5—8) extending in parallel ahead of and through the test station. Each plate 46 has an inclined lead-engaging ramp portion 48 disposed for co-operation with the successive fingers 24 thus to raise successive advancing component leads L heightwise of the conveyor, and onto a raised lead-supporting horizontal rail portion 50. The latter is co-operative with the pickers 44 as they are caused to receive the lifted leads L, L and to accelerate and decelerate them downstream relative to the fingers 24.

Angular speed of the short or input crank arm 34 is derived from a rotary stub shaft 52 (Figures 4, 5). The mentioned four-bar linkage 34, 36, 38, is such that when it has aligned each transferred component C with the test station 28 and ceased downstream motion, the pickers 44 are raised vertically to free that component and commence return or upstream movement for receiving the component arriving at the trailing end of the cams 50 and next to be tested. The stub shaft 52 is journaled in a gear housing 54 secured to a frame portion 56 of the machine. The housing 54 serves also to pivotally support the lower end of the crank arm 36 on a pin 58. Clockwise rotation of the crank arm 34 (Figures 5—8) and its shaft 52 is effected by means of a gear 60 (Figures 4, 5) on that shaft meshing with a drive gear 62 journaled in the housing 54 on a shaft 64 which also rotatably carries a cam 66 for a purpose later mentioned. The shaft 64 is herein shown as being normally continuously driven in appropriate timed relation to the conveyor 10 by means of an endless chain 68 (Figures 1, 6) passing over a lower sprocket 70, the hub of which is formed as a sprocket for the conveyor drive chain 32. (Means (not shown) is preferably provided for adjusting angular relationship of the driving shaft of the conveyor and a jackshaft portion of the transfer drive). It will be understood that normally continuous drive of the chain 32 and timed operation of the station 28 and the mechanism 30 may be derived from mechanism other than a motor, a clutch-brake unit, and a reducer (not shown) as referred

22

to in the cited U.S. Patent 3,669,309.

Structure of the test or inspection station 28 will be described referring mainly to Figures 7-9 inclusive. Slots 80, 80 respectively formed in the cam tracks 50 nest non-conductive blocks 82, 82, each of which mounts a lead-engageably, conductive vertical contact or probe 84 as shown in Figure 9. Upper ends of the probes are even with the tracks 50, and lower ends of the probes are connected to test circuit terminals 86, respectively. Cyclically co-operating with each of the probes 84 is a pair of upper, non-conductive clamps 88, 88, the lower edges of which are formed with aligned lead receiving notches 90 and lead-engaging, upwardly yieldable conductive contact pins 92 (Figure 9). It will be understood that appropriate current and voltage is directed to each component C when held clamped by its leads L being engaged by the pins 92, 92, when lowered by the clamps 88. Control and timing of the test current and voltage are preferably derived from pulsing as dictated by the computer 16.

For cyclically lowering the contact pins 92, 92, of the clamps 88, 88 onto the leads L of each component just as the leads have been brought to a halt by the downstream side of the notches 90 as the pickers 44 arrive at the left-hand extremity of their travel, the clamps 88 are carried by a bar 94 (Figures 1, 3, 5-8) secured to a lever 96. The latter is fulcrummed at one end on a pin 98 secured to the housing 54. The other end of the lever 96 carries a follower roll 100 co-operative with the periphery of the mentioned cam 66, engagement between the cam and roll being maintained by a spring 102 interconnecting the lever 96 and a pin affixed to the housing 54. The high locality of the cam 66 elevates and holds the clamps 88 raised to release each tested component C when its lead-pushing fingers 24 catch up with it, assuming the component passes its electrical test. If it does not qualify for the usage contemplated, the computer 16 is not signalled (or is correspondingly signalled) and accordingly circuitry controlling the conveyor drive means is at once deenergized.

In the event of a component failing its test at the station 28, and the conveyor stopping with the unacceptable component C under clamps 88, a machine attendant may remove the unacceptable component by pivoting the lever 96 clockwise until the bar 94 abuts a fastener securing the housing 54 to the portion 56 of the machine. If the unacceptable component stops under the guide shoes 104, the attendant may swing clockwise an arm 103 carrying the pair of guide shoes 104 from their full-line operative position shown in Figures 1, 2, 6 and 8 to their upper, dotted line out of the way inoperative position shown in Figures 1, 2, and 5. For this purpose

the arm 103 is pivoted on a pin 108 in a bracket 106 secured to the housing 54. A tension spring 110 normally urging the lower edge of the shoes 104 counter-clockwise into lead engageable position (determined by abutment with the bracket 106) as test-passing components C are moved from the station 28 downstream again by their fingers 24, is connected at a lower end of the arm 103 and at its upper end to a pin 112. This pin 112 is so located relative to the pin 108 that the arm will yieldingly be held in its inoperative position (indicated by dotted lines in Figures 1, 2, 5) against a stop. Now the attendant can have access to readily remove an unacceptable component C and, after determining acceptability of a suitable substitute component C in an auxiliary test station 112 (Figures 1, 2, 8), the proper replacement for component C will be deposited in its carrier 18 and the machine restarted when the shoes 104 have again lowered. Thus the pick-off fingers 24, which had been advancing a rejected component C, will now be co-operating with the under edges 114 of the guide shoes to restore the newly qualified component for travel at continuous, substantially constant conveyor speed in its pocket in the carrier 18.

Referring to Figures 1, 2, and 8, the auxiliary test station 112 may, of course, have different construction and location if desired, but will normally be adjacent to a convenient reserve supply (not shown) of the different substitutable components. As herein shown the station 112 comprises a bracket 116 secured to the housing 54 and supporting pairs of electrical test units 118 which may correspond to those provided and described for the automatic test station 28. Desirably the operator will, when necessary simply place the new component to be tested with its leads in the notches of the lower units 118, and then bear down on a hinged cover 120 (preferably transparent) carrying upper lead clamping test blocks 119 (Figures 1, 8) co-operative with the units 119. This encloses the new component and connects its leads in the testing circuitry by closing a contact 122 (Figures 1, 8) of a switch mounted on the cover with an adjustable screw 124 threaded in the bracket 116. Acceptability of the new component is verified by read-out on the computer 16 prior to positioning that component in its appropriate carrier 18. A tension spring 126 interconnecting the housing 54 and a projection on the cover 120 biases the latter clockwise to open position against a stop 128 as indicated in Figures 1 and 2, to facilitate placement of the component in the station 112 and removal therefrom.

Briefly to review operation of the illustrative machine and more especially its associated component test station 28 and transfer mechanism 30, it will be assumed that the

carriers 18 are respectively loaded with components C picked-off from the dispensers 14 by the pairs of fingers 24 and successively proceeding continuously downstream toward the station 28. The sequences of the leaded components has been appropriately predetermined by the computer 16 which will also successively control their proper electrical test and the timing of such tests at the station 28. It is important prior to reeling (or other processing) of the newly sequenced components at the station 12, to verify that no unacceptable component C is included and that elimination of such component be accomplished with minimum decrease in output of the machine.

On engagement of the leads of each component with ramp portions 48, it is raised to the level of the cam rails 50 by the front edges of the now vertical fingers 24. Timing of the four-bar linkage 34, 36, 38 of the mechanism 30, is such that the pickers 44, as indicated in Figure 5, are lowered over the pair of leads L preferably just as they reach the leading ends of the rail portions 50. Now the pickers 44 accelerate downstream to advance the component (while guided by the portions 50) ahead of its fingers 24 previously relied on for propulsion. The change in velocity imparted to each component by the transfer mechanism 30, and actuated by the power means normally continuously driving the conveyor 10 as hitherto noted, is for the purpose of enabling the test station 28 to operate automatically on the component being transferred when it becomes electrically insulated and stationary, thereby enabling the same component, when automatically tested, as "acceptable", to again be propelled by its fingers 24 without any stoppage of the machine.

At the left-hand extremity of travel of the pickers 44, as shown in Figures 5 and 6, they will be raised vertically from the portions 50 and from the leads L which are then located upon the probes 84, 84 respectively. Next, by reason of timed co-operation of a low region of the cam 66 with the follower roll 100, the clamps 88 are caused yieldingly to bring contact pins 92, 92 into lead engagement with the stopped component. Satisfactory verification of that component's presence and electrical character by the test circuitry does not signal for any stoppage of the conveyor 10, but an unsatisfactory test at once terminates operation of the conveyor, the test station 28, the transfer mechanism 30, and the processing station 12.

Upon rectification of a defect and substitution of an acceptable component in the appropriate conveyor carrier 18 as above noted, reel up of the verifier proper components may be continued. It will be appreciated that the transfer mechanism 30 and the test station 28 may be adapted for use directly

with component insertion machinery or other processing equipment in lieu of taping-reeling as at the station 12. In any case, a continuous high output of "good" components in proper sequence is assured by the invention.

WHAT WE CLAIM IS:—

1. A machine for successively testing or processing electronic components or the like comprising a continuously movable conveyor for carrying the components in sequential spaced relation in individual carriers of the conveyor, a stationary component test or processing station adjacent to the operating path of the conveyor, and means for transferring successive components from their respective carriers upstream of the test or processing station and presenting them one by one at the test or processing station and then restoring them to their respective carriers, downstream from said station, said transferring means including mechanism for changing velocity of the components relative to the conveyor whereby they can be presented to said station and tested or processed there while momentarily at rest before being restored to their respective carriers on the conveyor without stopping or retarding its continuous movement during operation of the machine.

2. A machine according to claim 1 wherein said mechanism is adapted for accelerating the components and comprises a four-bar linkage.

3. A machine according to claim 1 wherein the means for transferring the components is operatively connected to mechanism for driving the conveyor.

4. A machine according to claim 1 comprising power means for driving the conveyor, and mechanism connected to said power means for cyclically effecting co-operation of the transfer means and the station.

5. A machine according to claim 1 comprising a plurality of component dispensers disposed in alignment adjacent to the conveyor, and programmable means for causing the dispensers to load the conveyor with components arranged in selected predetermined sequence, the processing station being located downstream of the dispensers and adapted to determine acceptability of the successive components from their electrical characteristics, the construction and arrangement being such that continued operation of said conveyor and transfer means is contingent on acceptability of each component in said sequence as determined by the processing station in response to operation of said programmable means.

6. A machine according to claim 5 wherein the dispensers are respectively actuatable to release a component to the conveyor by electrical pulsing controlled by the programmable means, and the actuation of said station is



carriers 18 are respectively loaded with components C picked-off from the dispensers 14 by the pairs of fingers 24 and successively proceeding continuously downstream toward the station 28. The sequences of the loaded components has been appropriately predetermined by the computer 16 which will also successively control their proper electrical test and the timing of such tests at the station 28. It is important prior to reeling (or other processing) of the newly sequenced components at the station 12, to verify that no unacceptable component C is included and that elimination of such component be accomplished with minimum decrease in output of the machine.

On engagement of the leads of each component with ramp portions 48, it is raised to the level of the cam rails 50 by the front edges of the now vertical fingers 24. Timing of the four-bar linkage 34, 36, 38 of the mechanism 30, is such that the pickers 44, as indicated in Figure 5, are lowered over the pair of leads L preferably just as they reach the leading ends of the rail portions 50. Now the pickers 44 accelerate downstream to advance the component (while guided by the portions 50) ahead of its fingers 24 previously relied on for propulsion. The change in velocity imparted to each component by the transfer mechanism 30, and actuated by the power means normally continuously driving the conveyor 10 as hitherto noted, is for the purpose of enabling the test station 28 to operate automatically on the component being transferred when it becomes electrically insulated and stationary, thereby enabling the same component, when automatically tested, as "acceptable", to again be propelled by its fingers 24 without any stoppage of the machine.

At the left-hand extremity of travel of the pickers 44, as shown in Figures 5 and 6, they will be raised vertically from the portions 50 and from the leads L which are then located upon the probes 84, 84 respectively. Next, by reason of timed co-operation of a low region of the cam 66 with the follower roll 100, the clamps 88 are caused yieldingly to bring contact pins 92, 92 into lead engagement with the stopped component. Satisfactory verification of that component's presence and electrical character by the test circuitry does not signal for any stoppage of the conveyor 10, but an unsatisfactory test at once terminates operation of the conveyor, the test station 28, the transfer mechanism 30, and the processing station 12.

Upon rectification of a defect and substitution of an acceptable component in the appropriate conveyor carrier 18 as above noted, reel up of the verifier proper components may be continued. It will be appreciated that the transfer mechanism 30 and the test station 28 may be adapted for use directly

with component insertion machinery or other processing equipment in lieu of taping-reeling as at the station 12. In any case, a continuous high output of "good" components in proper sequence is assured by the invention.

WHAT WE CLAIM IS:—

1. A machine for successively testing or processing electronic components or the like comprising a continuously movable conveyor for carrying the components in sequential spaced relation in individual carriers of the conveyor, a stationary component test or processing station adjacent to the operating path of the conveyor, and means for transferring successive components from their respective carriers upstream of the test or processing station and presenting them one by one at the test or processing station and then restoring them to their respective carriers, downstream from said station, said transferring means including mechanism for changing velocity of the components relative to the conveyor whereby they can be presented to said station and tested or processed there while momentarily at rest before being restored to their respective carriers on the conveyor without stopping or retarding its continuous movement during operation of the machine.

2. A machine according to claim 1 wherein said mechanism is adapted for accelerating the components and comprises a four-bar linkage.

3. A machine according to claim 1 wherein the means for transferring the components is operatively connected to mechanism for driving the conveyor.

4. A machine according to claim 1 comprising power means for driving the conveyor, and mechanism connected to said power means for cyclically effecting co-operation of the transfer means and the station.

5. A machine according to claim 1 comprising a plurality of component dispensers disposed in alignment adjacent to the conveyor, and programmable means for causing the dispensers to load the conveyor with components arranged in selected predetermined sequence, the processing station being located downstream of the dispensers and adapted to determine acceptability of the successive components from their electrical characteristics, the construction and arrangement being such that continued operation of said conveyor and transfer means is contingent on acceptability of each component in said sequence as determined by the processing station in response to operation of said programmable means.

6. A machine according to claim 5 wherein the dispensers are respectively actuatable to release a component to the conveyor by electrical pulsing controlled by the programmable means, and the actuation of said station is



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arranged to be triggered by said pulsing.

7. A machine according to claim 5 wherein the conveyor comprises an endless chain including uniformly spaced pairs of fingers arranged to engage and advance oppositely extending leads of each component, and said transfer means includes ramp means co-operative with successive pairs of said fingers to raise the components heightwise relative to the chain and present them to said mechanism.

8. A machine according to claim 1 wherein the carriers of said conveyor are adapted to receive individually lead-bearing components, side by side and in predetermined sequence, and said station has lead-engageable means for electrically testing each component at a locality adjacent to the path of the conveyor, said transfer mechanism being located ahead of the test station and co-operative with the successive carriers to relatively advance each component with respect to its carrier and

present the component to the test locality, and the machine also comprising means operable in time relation to the conveyor for cyclically actuating the transfer mechanism and the test station to enable the latter to complete its test of a component while relatively advanced and before it is again received by its carrier.

9. A machine for successively processing electronic components or the like constructed, arranged and adapted to operate substantially as hereinbefore described with reference to the accompanying drawings.

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