

March 19, 1968

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3,373,869

TOWEL SORTER HAVING AN INFRARED DETECTOR

Filed Aug. 23, 1965

2 Sheets-Sheet 1

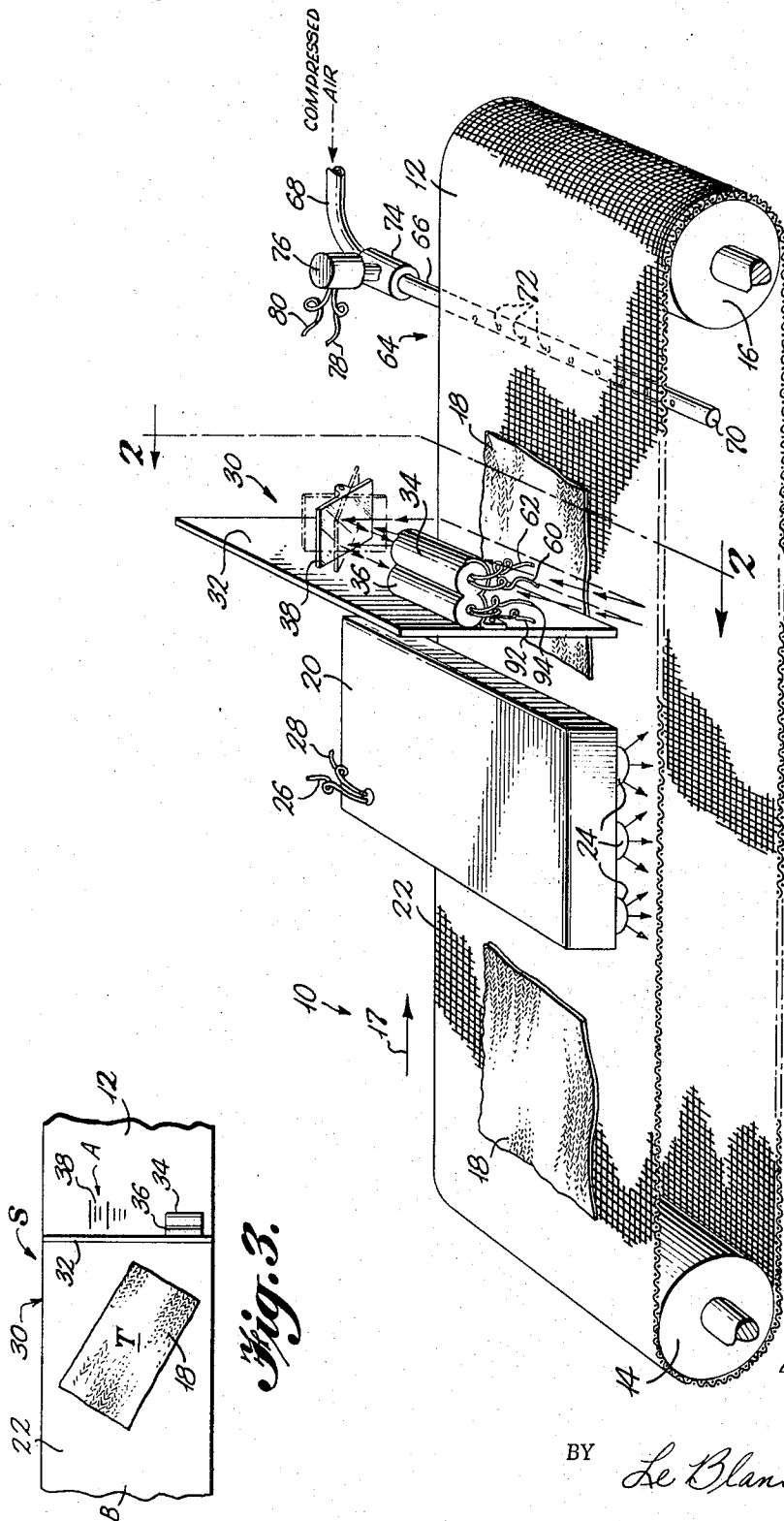


Fig. 1.

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Fig. 2.

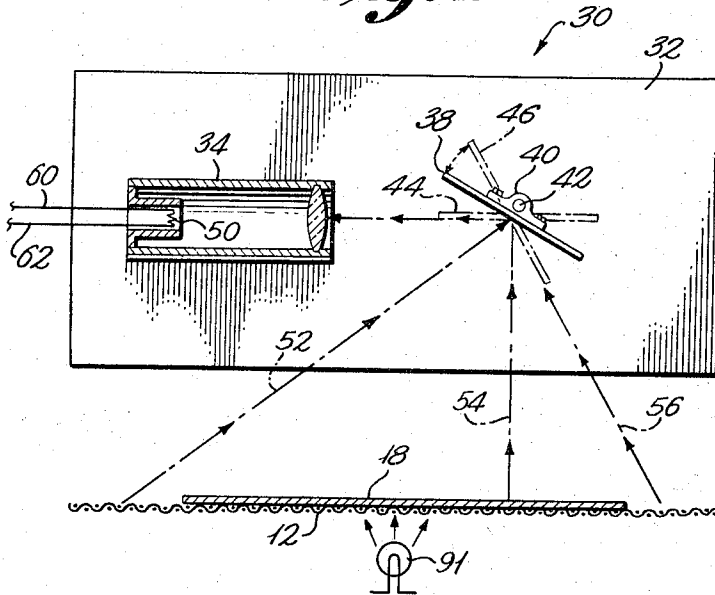
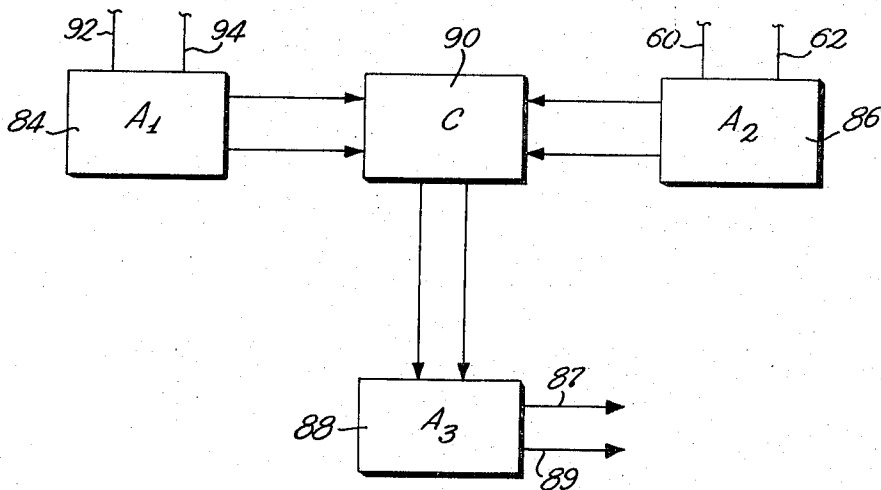


Fig. 4.



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TOWEL SORTER HAVING AN INFRARED DETECTOR

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Filed Aug. 23, 1965, Ser. No. 481,620
17 Claims. (Cl. 209—111.5)

ABSTRACT OF THE DISCLOSURE

Disclosed is a system for detecting foreign matter in articles and particularly abrasive materials remaining in towels cleaned by a commercial laundry. The towels pass along an open mesh conveyor belt beneath one or more heat lamps where they are heated several degrees above ambient. Downstream of the heat lamps is an infrared detector which is scanned across the towel to sense variations in re-emitted infrared radiation. The detector output is gated by a visible light system sensing the presence of a towel. A towel with too much abrasive is ejected by an air stream from below passing through the conveyor belt.

This invention relates to a detector for sensing foreign matter such as abrasive particles, radioactive materials, or the like, in fabrics, and more particularly, is directed to a device for inspecting laundry towels to make certain that they are free of undesirable foreign particles, especially abrasives.

It is very difficult and costly for an industrial towel laundry to give a guaranteed abrasive-free towel under the present methods of hand operation. In customary practice, the cloth towels may be used by such diversified establishments as service stations, factories, print shops, machine shops, etc. These are customarily loaned for a regular monthly fee to the user by the industrial laundry. They are picked up on a regular schedule and laundered after which they are ordinarily sent to a different customer. Usually only by chance will the same towel find its way back to the previous user.

Most conventional commercial laundry processes will clean the more easily wash-out portions or soluble soiling materials in a fabric towel, such as a conventional cloth towel. However, there often are wood splinters, wire shavings, saw dust, plastic, and grit of many types incorporated in the dirty towels that will not wash out easily or completely from the towel. These constitute undesirable foreign particles or matter which may remain in the towel after washing and which may cause serious damage particularly due to their abrasive qualities.

As an example, it is quite possible that a towel picked up for laundering from a machine shop may contain iron filings and shavings from machine tools. As this towel is laundered by the conventional process, the grease in the soiled towel may come out, but many times the filings and shavings remain. The next user of the supposedly clean towel may suffer substantial injury to body, hands, or especially face if the towel carrying the iron filings is used for drying the face after washing. In addition to personal injury, which can be caused by foreign matter in towels, property damage is also a problem. That is, should the towel at a service station be used to wash or dry an expensive automobile, the auto surface may be seriously scratched by the abrasive particles in the towel.

A further feature of the present invention resides in the fact that the system will detect radioactivity. Towels or cloths used in radioactive installations such as laboratories or the like, may retain certain residual radioactivity in the towel for a long period of time as small radioactive particles of dust or the like. This radioactive par-

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ticle detection is made possible through the provision of a wide band infrared detector which will not only detect most of the common foreign particles, but which will produce an output when exposed to alpha or gamma rays.

In the system of the present invention, the towel to be monitored after laundering is placed by hand on a suitable conveyor belt. This belt is preferably of an open mesh construction for a reason more fully described below and conveys the belt beneath one or more infrared heat lamps where the temperature of the towel is raised several degrees above ambient temperature. The foreign particles having different surface characteristics as well as different physical and chemical properties from that of the towel material itself will absorb a different amount of heat energy than the corresponding area of the surrounding towel and hence will rise to a slightly different temperature than the towel material. Most of the darker metallic foreign particles are better absorbers of radiant infrared energy than is the light colored cloth material of most towels, so that generally the foreign particles will be at a higher temperature. However, some types of foreign particles are poor absorbers of radiant heat energy and hence may be at a lower temperature. The device of the present invention is so constructed as to be capable of detecting either type of contaminant or foreign matter in the towel.

Upon leaving the area of the heat source, i.e., the infrared lamps, the towel is carried along the conveyor and in so doing re-radiates some of the heat previously absorbed. The towel during this time passes beneath a detector preferably in the form of a suitable photo-voltaic device sensitive to infrared radiation which produces an output in accordance with the radiation impinging on the detector. The detecting station preferably includes an oscillating or nutating mirror for optically scanning the surface area of the towel and directing the radiation from the towel to the infrared detector. Variations in radiation departing substantially from the normal predetermined radiation emanating from the towel is sensed in a suitable electrical circuit connected to the detector to produce an output signal indicative of excessive variations in the radiation emanating from the towel either above or below a preestablished level.

An important feature of the present invention resides in the provision of a novel ejector for automatically ejecting a "dirty" towel or towel having too many foreign particles from the surface of the conveyor. To this effect, the conveyor belt is preferably of a suitable mesh construction of fairly open weave such that a blast of air from beneath the conveyor belt may be used to eject the towel from the belt. The electrical output of the detecting station is applied to a suitable solenoid valve in an air line supplying the ejector mechanism such that the valve is opened and a pulse of high pressure air applied to the ejector so as to eject undesired towels. Towels which pass through the detector without indicating excessive variations in infrared radiation do not energize the ejector but pass along to the end of the conveyor where they may be deposited in a suitable receptacle or hopper for further processing in the laundry.

In some instances, it may be necessary to scan both sides of the towel in order to be absolutely sure that excessive foreign matter does not remain in it. In this case, two complete systems may be provided, one for scanning one side after which the towel may be dropped onto a second conveyor belt where the opposite side of the towel is scanned and foreign particles, if any, detected in a manner similar to that for the first side. In this case, a separate ejection mechanism is provided for each of the detecting or sensing systems.

While various infrared detection systems have been pro-

vided for a variety of purposes, these systems have insofar as applicant is aware been related for the most part to color temperature (i.e. principal radiating frequency) detection of various radiating bodies and have not insofar as applicant is aware been suited to detection of abrasive particles or the like in cloth. One of the principal reasons for this lies in the fact that prior infrared detector devices have often involved only the detection of targets or point sources differing in color temperature from a more or less uniform generalized background. Therefore, they are not applicable to inspection systems such as that disclosed where the "background" device, i.e. the towel or other cloth article to be inspected, is itself only periodically or intermittently before the detector and does not provide a continuous and substantially uniform color temperature background. Similarly, prior detection devices have incorporated no means for automatically rejecting unsatisfactory articles of this type.

It is therefore one object of the present invention to provide an improved article monitoring system.

Another object of the present invention is to provide an improved system for the detection of foreign matter in fabrics.

Another object of the present invention is to provide a system for monitoring the content of abrasive foreign particles in towels and other fabrics.

Another object of the present invention is to provide a system for sensing the presence of foreign matter and/or radioactive particles in fabrics.

Another object of the present invention is to provide a novel system for detecting abrasive particles such as iron filings and the like in cloth and particularly cotton towels. In the system of the present invention, the freshly laundered towel is subjected in an automatic conveyor device system to a source of heat preferably in the form of a plurality of infrared lamps positioned over a traveling conveyor belt. As a result of the passage of the towel adjacent the heat source, the towel temperature is increased in accordance with the nature of the material from which the towel is woven or fabricated. However, foreign particles in the towel will absorb greater or lesser degrees of heat depending upon the nature of the foreign particle material and this different temperature is later detected by an infrared detector positioned adjacent the traveling belt downstream of the heat source. Important features of the present invention include the provision of a second radiation detector preferably in the form of a visible detector for showing the presence of a towel to be monitored and the further provision of an air jet or other suitable fluid agent for automatically removing unsatisfactory towels from the conveyor system.

These and further objects and advantages of the invention will be more apparent upon reference to the following specification, claims and appended drawings, wherein:

FIGURE 1 is a diagrammatic view illustrating the novel infrared article monitoring system of the present invention;

FIGURE 2 is a similar view showing the details of the scanning system of FIGURE 1;

FIGURE 3 is a diagrammatic plan view of the detector portion of the system of FIGURE 1; and

FIGURE 4 is a block diagram of the electrical circuit connections for the monitoring system of FIGURE 1.

Referring to the drawings, the overall system generally indicated at 10 in FIGURE 1 comprises a conveyor belt 12 adapted to move over a pair of rollers or pulleys 14 and 16, one of which is preferably driven in a conventional manner to cause the top side of the conveyor belt to move in the direction of the arrow 17 in FIGURE 1.

A series of towels, two of which are illustrated at 18 in FIGURE 1, is laid by hand on the traveling conveyor belt, which is preferably of open mesh construction and moves at a rate in the neighborhood of from 45 to 60 feet per minute.

The towel first passes beneath a heat source 20 posi-

tioned over, but spaced from the upper surface 22 of the conveyor belt. This heat source may be of any desired type, but preferably takes the form of several heat lamps, three of which are illustrated at 24, which direct infrared radiant energy downwardly from the source onto the upper surface 22 of the conveyor belt and consequently to the towels as they pass along the conveyor belt beneath the heat source. The heat source 20 may be energized from a suitable electrical power supply by way of power supply leads 26 and 28. The infrared heat lamps 24 are sufficient in number and size to heat the towels several degrees above normal room temperature.

The background or large portion of the heated area is that of the cotton cloth or other cloth material that the towels are made from. This presents to any detecting apparatus a relatively broad field of substantially uniform temperature. However, if there exists foreign particles in the towel, such as grit, hard plastic, saw dust, metal shavings or the like, these will gather heat from the radiant heat source lamps 24 at a different rate than that of the material of towel 18. Metals normally absorb more heat than a white cotton cloth towel so that any metal shavings in the towel rise to a higher temperature during passage beneath the heat source 20, i.e. they absorb infrared radiation at a greater rate. Consequently as the towel passes beyond the heat source, these particles radiate the absorbed energy at a correspondingly greater rate to the surrounding ambient atmosphere. Similarly, the radiation from foreign particles constituting a poor absorber of heat energy radiate into the surrounding atmosphere upon passage beyond the heat source at a lower rate than the surrounding towel material.

From the heat source 20, the towels, such as towels 18, pass along with the conveyor belt such that they subsequently move beneath a detecting station generally indicated at 30. This station comprises a vertical panel 32 suitably supported by means (not shown) above the conveyor belt slightly downstream of the heat source 20. Mounted on this panel are a pair of side-by-side optical radiation detectors 34 and 36. Detector 34 is sensitive to infrared radiation such that it produces an electrical output indicative of the amount or magnitude of infrared energy impinging upon it. Detector 36 which is of similar construction is preferably suitably modified by appropriate filters or the like such as to be sensitive to one or more bands of visible radiation or may be of completely different construction such as a phototube sensitive to the entire visible spectrum. The light (both visible and invisible) emanating from the upper surface 22 of the conveyor belt (or from an object such as a towel 18 positioned thereon) impinges upon a reflecting surface or mirror 38 and is directed from the mirror 38 onto the sensitive elements of the detectors 34 and 36. As best seen in FIGURE 2, mirror 38 is rigidly attached by a bracket 40 to a shaft 42 rotatably received through a bearing or other support (not shown) on the panel 32. Through the use of suitable oscillatory drive means, the mirror is preferably oscillated from the dotted line position illustrated at 44 in FIGURE 2 through the solid line position shown to the dotted line position illustrated at 46. Light reflected from the mirror 38 is collected by a suitable lens 48 of the detector 34 (and by a suitable lens (not shown) of the detector 36) so that the light is focused on the sensitive element 50 of the detector 34 and on the corresponding element of detector 36.

By means of the oscillating or nutating movement imparted to the mirror 38 between the dashed line positions 44 and 46 of FIGURE 2, the upper surface 22 of the traveling belt 12 is transversely scanned. The incremental areas transversely of the conveyor belt from which light is reflected and focused on the sensitive element 50 by the lens 48 are indicated by the dashes and arrows forming the optical lines 52, 54 and 56 corresponding to the respective positions of the mirror 38 during a half cycle of oscillation. That is, when mirror 38 is in the dashed line position 44, optical information is collected from the

area adjacent the origination of optical line 56. When the mirror is in a 45 degree position with respect to the horizontal or the solid line position as illustrated, the information collected is adjacent the origination of optical line 54, whereas when the mirror approaches the near vertical dashed line position illustrated at 46, the opposite edge adjacent the origin of optical line 52 is being sensed. The mirror 38 may be driven from any conventional source, such as a conventional oscillatory motor preferably powered from a conventional 60 cycle AC outlet.

If the mirror is caused to oscillate or nutate at 60 strokes per second by a suitable solenoid or oscillatory drive connected to a 60 cycle household outlet, and if the towel travels at a speed of one foot per second, i.e., 60 feet per minute, then the towel is scanned at a minimum of approximately five scans per inch of its traveling length, which has been found sufficient to adequately detect foreign particles remaining in the towels. Where more frequent scanning of the towel is desired, lower towel speeds, i.e. 45 feet per minute, can be utilized, or the oscillating frequency of the mirror can be increased. The drive motor for the mirror, which may be mounted either on the panel 32 or away from the panel and mechanically coupled to the mirror causes the mirror to pivot with its central shaft 42 connected midway between the mirror ends in a back and forth motion about this center pivot much like a child's see-saw motion. This causes the towel to be scanned as it passes through the line of sight of the mirror to the conveyor belt. The two detectors or photocells 34 and 36 may be of conventional construction with detector 36 provided to detect ordinary visible light. This detector is provided to assure only the detection of the towel and not all of the conveyor belt. The towel may sometimes be placed on the conveyor belt 12 such that it is crooked or perhaps such that a small corner constitutes the leading edge of the towel in the manner illustrated in FIGURE 3. In the event this happens, detector 36 permits the effective scanning of even this crooked or slanted towel, by only permitting the completion of an electrical circuit when the light to detector 36 is interrupted or modified by the presence of a towel on the conveyor 12 as the light beam is reflected by the scanning mirror 38.

Detector 34, as previously mentioned, is preferably a conventional infrared detector. This detector senses changes in temperature of incremental areas of the towel. If there is metal or abrasive material, it will be found that these radiate or lose heat at a different rate than the towel itself. Therefore, there is a change in the supply of radiant heat to the detector when a portion of a towel containing abrasive material is scanned. This causes a change in the output of the infrared detector 34 which appears as a changing electrical signal on the detector output leads 60 and 62.

A further important feature of the invention includes an ejector generally indicated at 64 comprising a fluid pipe 66 having one end 68 suitably coupled to a source (not shown) of pressurized gas preferably air under pressure. The other end 70 of the pipe is closed off and adjacent this end, the pipe is provided with a plurality of apertures 72 adapted to direct air upwardly through the conveyor belt 12. These apertures are preferably not perfectly vertical, but slant so as to impart a force component to a towel passing along the conveyor belt transverse to the conveyor belt so as to lift the towel off of the surface 22 of the belt and convey it a short distance to the side thereof where it may drop by gravity into a suitable receptacle positioned along side the conveyor belt at the location of the ejector 64. Towels collected in this receptacle are considered rejects requiring either reprocessing or special processing so as to remove undesirable foreign particles. In the event the towels are not ejected by ejector 64, they pass along to the end of the conveyor where they may drop off the belt passing around roller 60 into a second receptacle for collection and packaging for eventual supply to a customer and reuse as being satisfactorily

laundered. Pressurized air is supplied to the apertures 72 in the ejector by way of a normally closed air valve 74, pulsed temporarily to an open position for the passage of air therethrough by an electrical solenoid 76. The solenoid is energized over input leads 78 and 80 connected to the opposite ends of the solenoid coil.

In the event the towel is found to have abrasive material in it, the solenoid valve 74 is energized by way of leads 78 and 80 from the electronic circuitry illustrated in FIGURE 4. This circuitry includes a plurality of amplifiers 84, 86 and 88, labeled A_1 , A_2 and A_3 , respectively, and a coincidence circuit 90. The input of amplifier 86 is coupled to leads 60 and 62 so as to receive a signal from the infrared detector 34. Similarly, the input of amplifier 84 is coupled to leads 92 and 94 to receive a signal from the visible light detector 36. The outputs of these amplifiers are fed to the coincidence circuit 90 in turn feeding an output to amplifier 88. The output of amplifier 88 on leads 87 and 89 controls the signal to the solenoid valve leads 78 and 80.

In operation, it is most likely that a towel occasionally will be placed on the conveyor belt in a manner other than square, i.e., with a leading or projecting corner somewhat in the manner illustrated in FIGURE 3. Thus perhaps a corner of the towel will be scanned first and should this happen, the infrared scanner will at this time also scan a large portion of the conveyor belt and absent the improved structure and circuitry herein disclosed might otherwise give a false alarm. This is prevented by providing the visible light photocell or visible detector 36 adjacent infrared detector 34, but slightly upstream of the infrared detector. Thus the visible optical system scans the towel slightly before it is scanned by the infrared system.

As the towel enters the visible light beam from a visible light source 91 such as a suitable lamp or elongated fluorescent bulb beneath the conveyor, that portion of the towel that interrupts or otherwise modifies the light beam passing through the open mesh conveyor to detector 36 produces a gating signal which is amplified in amplifier 84 connected to the photocell by leads 92 and 94. For the purpose of providing visible light for the detector 36, a suitable light source 91 may be placed beneath the conveyor belt to project light upwardly through the belt in such a manner as to be intercepted or cut off by the towel. Alternatively, light reflected from above the towel may be utilized to energize the visible light detector, and this detector may simply sense a change in reflected light from the top surface of the conveyor belt as occasioned by the passage of a white towel or a towel otherwise brighter, i.e., having greater visible optical reflection, than the conveyor upon which it is carried. In certain cases, the source for the reflected light may be simply background light in which the system is operated. When the visible light system is interrupted, this information is passed through amplifier 84 and is placed on one grid of a coincidence detector tube provided in the coincidence circuit 90. When the infrared signal scans the towel and abrasive material is found, this causes a change in the output of the infrared detector 34 and changes the signal to the second amplifier 86. The output from amplifier 86 is applied to the other grid of the coincidence tube in circuit 90. Thus, the output information of the presence of abrasive material on the towel passes through amplifier 86 and is sent to the other grid element of the coincidence tube in circuit 90 where it is gated by the signal from amplifier 84 applied to the first mentioned grid. For the vacuum tube in coincidence detector 90 to conduct or send information to the third amplifier 88, two conditions or signals must occur simultaneously or be present. First, there must be a signal indicating that there is a towel obstructing rays of light to the photocell detector 36 and there must be additional information that there exists abrasive material as sensed by the infrared detector 34 and supplied to its output terminals 60 and 62 and

hence to amplifier 82. If these two signals are present then amplifier 88 receives a signal and pulls in a suitable solenoid relay completing a power circuit to the terminals 78 and 80. This in turn opens the solenoid valve 74 sending a blast of air beneath the towel causing it to be blown from the conveyor belt to the side of the conveyor belt and into a suitable container placed there to receive it.

The light or optical radiation for the photocell detector 36 preferably comes from a fluorescent or incandescent tube or strip light mounted beneath the conveyor belt. The conveyor belt 12 is preferably made of a net like material similar to what is known as cheesecloth or fishnet of a heavy enough material in gauge to withstand tensions. However, at the same time, the conveyor belt must permit the light to pass through the small openings in it and also permit the air or steam used to eject the towels from beneath the conveyor. The material of the belt is similar to a fine fishnet with many small openings similar to window screen wire or hardware cloth. It should have a mesh with square openings therein of approximately $\frac{1}{32}$ of an inch in width and length to permit the adequate flow of ejecting fluid. The conveyor belt is preferably made of cotton so that most of the incident infrared radiation is reflected. In any event, not too much heat radiation is absorbed by the belt due to its surface configuration, i.e. the relatively open nature of the mesh. That is, most of the radiant energy passes through the open mesh construction. Conventional toweling on the other hand which also may be made of cloth, but may be made of other materials, usually is made much finer or of a more close weave and conventionally will absorb more energy per unit area than the conveyor belt. Experimentation has indicated that particles of non-metallic abrasive material usually (but not always) absorb less heat and radiate the heat into the ambient atmosphere after passing the heat source at a lower or slower rate than the towel material. However, as distinguished from plastics, dust and other abrasives, iron filings or metal shavings and filings have been found to absorb more heat than the cloth towel and tend to radiate the heat at a greater rate to the infrared detector 34 than the material of the towel. The absorption rate and hence radiation rate for the relatively small increases in temperature are determined primarily by two factors, namely (1) the surface characteristics of material, and (2) the quantity of material in a given incremental area. For each type of towel to be processed, the normal towel radiation must be empirically ascertained between reasonable limits and towels ejected only when the infrared radiation exceeds these limits.

It is of course apparent that the permissible quantity of foreign matter in a towel will vary in accordance with the nature of the foreign matter present and in accordance with the nature of the towel itself. Small amounts of dust and other materials may be tolerated perfectly well in the rougher cloth towels whereas excessive amounts of these abrasives could not be tolerated. On the other hand, small amounts of metal filings and the like even in the rougher towels are generally considered undesirable and would necessitate rejecting the particular towel. Various provisions can be made for adjusting the permissible quantity of foreign material in the towel before the ejection solenoid is energized. One of the ways to adjust these variables is to vary the spacing between the heat source and the detectors. In this way, the amount of radiation sensed by the detectors will be decreased in proportion to any increase in spacing between the detectors and the heat source since by the time the towels reach the detectors, they will have radiated for a longer time and will be at a lower temperature so as to radiate at a lower rate. In addition to these and other mechanical adjustments, the amplifier gains and biases in the electrical circuit may be modified and adjusted in a well known

manner to provide impurity threshold levels which must be exceeded before a towel is ejected.

In order to permit a towel to be properly ejected from the conveyor it is desirable that the solenoid valve 74 be energized after the towel has moved from underneath the detectors 34 and 36. This necessitates some provision for time delay so as to delay the solenoid valve energization after detection of impurities to permit the towel to pass from underneath the detectors to the ejector. In order to provide this, the coincidence circuit 90 not only includes a coincidence tube of the type generally referred to as No. 5725, having two input grids, but the output of this coincidence tube preferably is used to trigger an adjustable one-shot multivibrator. The adjustment of the multivibrator permits some adjustment of the air injection system actuation and will generally provide the required amount of delay. If more delay is needed, this may be obtained by providing a phantastatron circuit for additional adjustable delay in a well known manner. The one-shot multivibrator in the circuit 90 feeds through the amplifier 88 causing closing of a relay (not shown) so as to deliver electric current to the solenoid valve and send a blast of air to eject the towel.

The gain of the amplifier stages in each of the amplifiers 1, 2 and 3, is preferably adjustable so as to vary the size and number of abrasive particles embedded in the towel necessary to produce ejection. By this gain adjustment is possible to prevent the ejection of towels that are only slightly dirty or have only a few small particles. Also by varying the optical lens systems in the detectors 34 and 36, it is possible to vary the sensitivity of the system in terms of incremental area scanned and thus the quantity of abrasive particles necessary to produce ejection. Other factors affecting the sensitivity as previously discussed are the scan speed and the conveyor speed. All these factors must be selected empirically for the particular towels being processed and the permissible limits for an acceptable towel.

Usually when a towel or cloth is exposed to radioactivity, the reason the towel remains radioactive after it is washed is that small particles of radioactive dust remain in the towel after washing. Through the selection of a suitable broad band infrared detector 34, it is possible in the system of the present invention to produce an output from the infrared detector when it is exposed to alpha or gamma rays. Infrared detectors of this type are readily available and one usable in the present invention is currently manufactured by the Davers Corporation, Series 100. This is a photovoltaic unit which is so mounted that when struck by an alpha ray, it will give off an electrical output.

It is apparent from the above that the present invention provides a novel system for examining cloth materials and particularly towels for the presence of foreign particles including especially abrasives, but also radioactive materials. Important features of the system include the provision of an infrared source and infrared detector for sensing the infrared heat radiation of scanned areas of the towel downstream of the infrared source. In order to avoid improper operation of the system a visible light detector and preferably a visible light source is positioned adjacent the infrared detector but slightly upstream therefrom so as to gate the infrared output in accordance with the presence or absence of a towel in the scanning area. When the two detectors indicate both the presence of a towel in the scanning area, then an air ejection system is energized after a suitable time delay so as to eject the towel from the conveyor belt.

The individual components of the overall system may be of conventional construction, the improvement offered by the present invention being in the nature of the specific combinations herein shown and described. For example, the amplifiers 84, 86 and 88 are of conventional wide-band construction, preferably direct coupled and operable

from relatively high frequencies down to very near DC. That is, frequencies in the neighborhood of one cycle per second or less should be amplified and passed through these amplifiers. Similarly, the coincidence or gating circuit 90 are of conventional construction and although described in conjunction with a conventional coincidence tube and multivibrator delay arrangement may also incorporate conventional solid state circuits. Optical detector 36 is preferably similar to infrared detector 34, but provided with a suitable filter to filter out any infrared light before it reaches the sensitive element of that detector. Conversely, detector 36 may be a conventional phototube of completely different construction but similarly sensitive to visible light, while insensitive to infrared. The system of the present invention is suited not only to the more or less white or cream colored towels conventionally provided by commercial laundries, but when used with an interrupted light beam to detector 36, the system is equally adapted to towels and cloth materials of another color. Even when employing reflected light it is possible through suitable well known optical filter techniques to increase the sensitivity of the detector 36 to the particular color of the towel 18 being processed so as to clearly distinguish this towel from the material of the conveyor and properly gate the infrared portion of the unit in accordance with the presence or absence of a towel. It is preferred that the sensitivities of the two detectors 34 and 36 do not overlap, i.e., that the bands for which they produce output signals have no area of overlap or coincidence so that the gating signal for the infrared system is completely independent, i.e. sensitive to some optical frequency outside of the infrared band sensed by detector 34. However, some overlap may be tolerated.

In addition to or as an alternative to the ejector mechanism the device of the present invention may be provided with a suitable device for squirting washable ink onto a towel in response to an output signal from amplifier 88, the ink providing a visible indication that the towel is not satisfactorily free of foreign particles.

As used throughout this specification and the following claims, the terms "optical" and "light" are meant to include infrared and ultraviolet as well as the visible spectrum. When not so intended the modifying terms "heat," "infrared" or "visible" are employed.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. An optical detection system comprising a conveyor, a source of heat energy adjacent said conveyor for heating articles passing along said conveyor, an infrared radiation detector adjacent said conveyor downstream of said source for producing an output signal in response to the passage of a heated article on said conveyor by said detector, an ejector adjacent said conveyor and coupled to said detector receiving said output signal, and means sensitive to optical radiation from an article at a frequency other than said infrared for gating said signal to said ejector.

2. A detection system according to claim 1 wherein said ejector comprises pneumatic means for blowing an article off said conveyor.

3. An optical inspection system comprising a gas pervious conveyor belt for transporting a series of articles to be inspected, a heat source positioned adjacent said conveyor belt for heating said articles, an infrared radiation detector adjacent said conveyor belt downstream of said heat source for producing an electrical output signal in

response to the passage of a heated article on said conveyor belt by said detector, and a pneumatic ejector positioned beneath said conveyor belt for ejecting articles therefrom, said ejector being coupled to receive the output signal from said detector.

4. An inspection system according to claim 3 wherein said conveyor belt is of open mesh construction.

5. An inspection system according to claim 4 wherein said belt is provided with square openings therein of approximately $\frac{1}{32}$ of an inch.

6. An optical inspection system comprising a gas pervious conveyor belt for transporting a series of articles to be inspected, a heat source positioned adjacent said conveyor belt for heating said articles, an infrared radiation detector adjacent said conveyor belt downstream of said heat source for producing an electrical output signal in response to the passage of a heated article on said conveyor belt by said detector, means for focussing infrared radiation from an incremental area of said articles on said detector, means including an optical reflector for causing said focussing means to scan across an article transversely of the direction of movement of said conveyor belt, and a pneumatic ejector positioned beneath said conveyor belt for ejecting articles therefrom, said ejector being coupled to receive the output signal from said detector.

7. An inspection system according to claim 6 including a visible light detector adjacent said conveyor belt for gating said electrical signal in the presence of an article adjacent said infrared detector.

8. An inspection system according to claim 7 wherein said visible light detector is positioned adjacent said infrared detector but upstream thereof.

9. An optical inspection system for towels comprising a gas and light pervious mesh conveyor belt for transporting a series of cloth towels to be inspected, a source of radiant heat energy positioned adjacent said conveyor belt for heating said towels a few degrees above ambient temperature, an infrared radiation detector adjacent said conveyor belt downstream of said heat source for receiving radiant heat energy from said towels and producing an electrical signal in response thereto, electrical means coupled to said infrared detector for sensing variations in said signal caused by foreign matter in said towels having radiant energy emitting characteristics differing from the characteristics of said towels, means for focussing infrared radiation from an incremental area of the surface of said towels on said detector, means including an optical reflector for causing said focussing means to scan across said towels transversely of the direction of movement of said conveyor belt, and a pneumatic ejector positioned beneath said conveyor belt for ejecting articles therefrom, said ejector being coupled to said infrared detector and responsive to predetermined variations in said electrical signal.

10. An inspection system according to claim 9 wherein said scanning means comprises an oscillating mirror.

11. An inspection system according to claim 10 including a visible light detector adjacent said infrared detector, means including said mirror for focussing visible light from an incremental area of said towels onto said visible light detector, and means coupling the output of said visible light detector to the output of said infrared detector whereby the latter is gated by the former when a towel is present adjacent said detectors.

12. An inspection system according to claim 11 including a coincidence circuit having a time delay coupling the outputs of both of said detectors to said ejector.

13. An optical inspection system for towels comprising a gas and light pervious mesh conveyor belt for transporting a series of cloth towels to be inspected, a source of radiant heat energy positioned adjacent said conveyor belt for heating said towels a few degrees above ambient temperature, an infrared radiation detector adjacent said conveyor belt downstream of said heat source for receiving radiant heat energy from said towels and producing

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an electrical signal in response thereto, a visible light detector adjacent said infrared detector, means including an oscillating mirror for focussing optical radiation from an incremental area of the surface of said towels onto each of said detectors, means including a coincidence circuit having a time delay coupled to receive the outputs of each of said detectors, said detector output receiving means producing an electrical signal in response to predetermined variations in infrared radiant energy from said towels, and a pneumatic ejector positioned beneath said conveyor belt for ejecting towels therefrom, said ejector being coupled to said coincidence circuit and acting in response to an output signal therefrom.

14. An inspection system according to claim 13 including a visible light source beneath said conveyor belt normally directing light through said conveyor belt onto said mirror, said visible light detector being responsive to decreases in light from said visible light source caused by the passage of a towel between said visible light source and said mirror.

15. An inspection system according to claim 13 wherein said ejector includes means for supplying a blast of air both upwardly from and transversely of said conveyor belt to blow a towel off said belt, and an electrically operated air valve responsive to the output from said coincidence circuit.

16. An optical detection system comprising a conveyor,

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a source of heat energy adjacent said conveyor for heating articles passing along said conveyor, a detector of infrared radiant energy adjacent said conveyor downstream of said source for producing an output signal in response to the passage of a heated article on said conveyor by said detector, means for focusing infrared radiation from an incremental area of said articles on said detector, means including an optical reflector for causing said focusing means to scan across an article transversely of the direction of movement of an article along said conveyor, and means coupled to said detector and responsive to the output of said detector for distinguishing between articles on said conveyor.

17. A system according to claim 16 including visible light sensing means coupled to said detector for gating the output of said detector in accordance with the presence of an article adjacent said detector.

References Cited

UNITED STATES PATENTS

20	2,493,785	1/1950	Strickland	-----	209—111.7	X
	2,645,343	7/1953	Nemir	-----	209—74	X
	3,206,603	9/1965	Mauro	-----	250—83.3	
	3,216,568	11/1965	Jacob et al.	-----	209—111.7	
25	3,245,533	4/1966	Rottmann	-----	209—111.7	

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