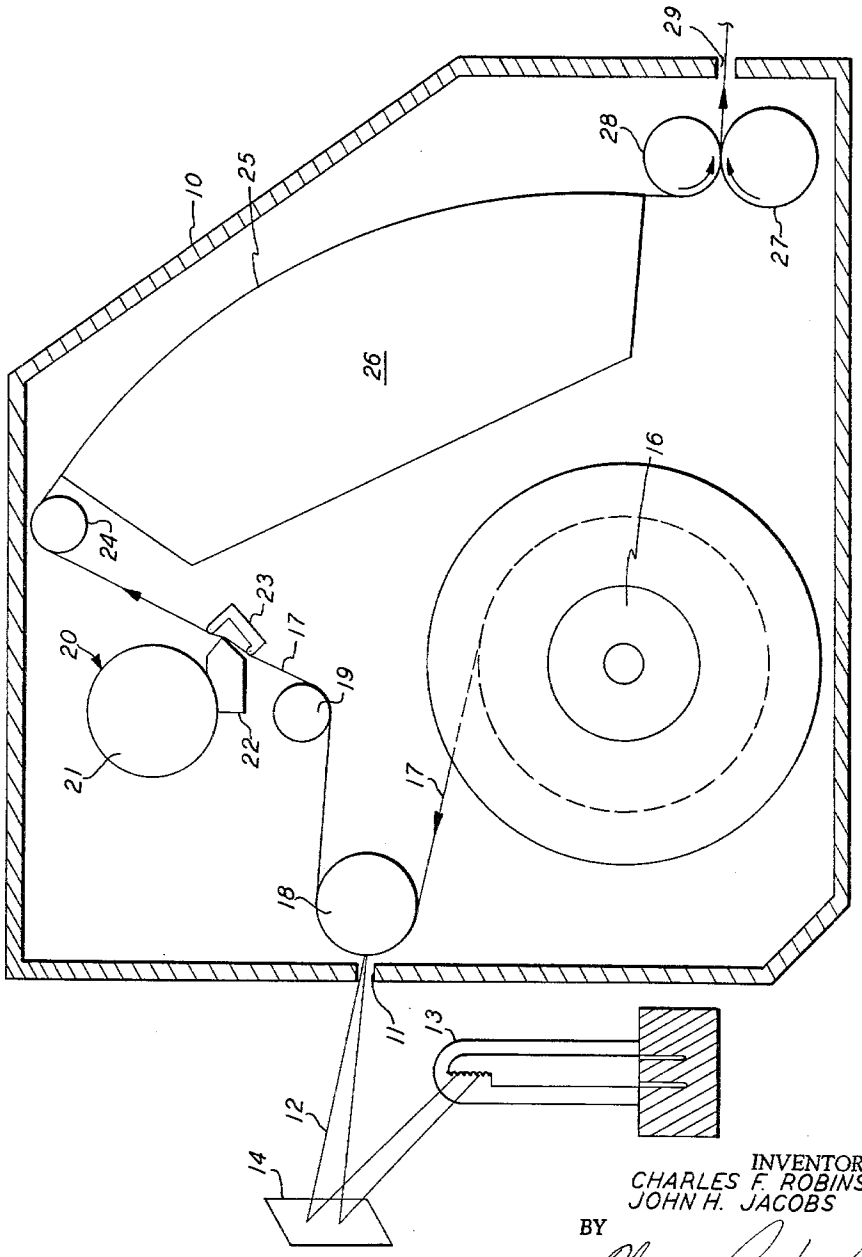
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RAPID PHOTOGRAPHIC DEVELOPING

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RAPID PHOTOGRAPHIC DEVELOPING

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Continuation of application Ser. No. 681,804, Sept. 3, 1957. This application Feb. 21, 1962, Ser. No. 174,918
5 Claims. (Cl. 96—63)

This application is a continuation of our United States patent application Serial No. 681,804, filed September 3, 1957, now abandoned. This invention relates to a high speed process for developing photosensitive emulsions and has great utility for rapid access photographic recording. Because of this utility the invention is particularly described in its application to this field although in no sense so limited.

As dynamic recording has increased in application and importance, there have evolved fields of use in which a very short access time is desirable. The term "access time" is used to indicate the time interval between the exposure of a photosensitive recording paper to a light stimulus to be recorded and the presentation of the resultant record for visual observation. The terms "photographic paper" and "recording paper" are used throughout the specification and claims to include photosensitive emulsions disposed in any suitable support such as paper, film or oher usable medium.

Wind tunnel and flight testing represent examples of testing procedures wherein rapid access is of considerable value. Conditions of operations can be changed with greater facility and flexibility if the conditions undergoing test can be recorded and visually observed in a brief rather than a prolonged interval of time.

Previously conventional photographic recording techniques generally referred to as oscillography have involved the exposure of an entire roll of a record paper to the information to be recorded with subsequent and separate chemical development of the roll thus exposed. In this procedure a record roll of say approximately 250–400 feet in length is entirely exposed before its removal from the oscillographic recorder and its subsequent development by presently conventional means. This procedure thus represents a rather prolonged access time of minutes or even hours.

We have now devised fundamental modifications in the usual developing techniques permitting development of the latent image produced by exposure of a photosensitive medium within a very brief interval subsequent to exposure and even more importantly continuously and concurrently with exposure of succeeding increments of the mediums. By our technique we are able to produce for visual observation a photographic record of excellent resolution and contrast with an access time of approximately one second providing the record transport is maintained at a rate sufficient for the medium to emerge from the process in this interval. By way of explanation, it takes a finite space in which to carry out the process and the access time is dependent then not only on the potential speed of the process but also on the record transport speed through this finite space. In other words, at very low recording speeds, paper travel and not our developing technique becomes the limiting factor in access time.

Basically the invention comprises in one aspect a process for developing a photographic material having a photosensitive emulsion supported on a backing preferably of paper. The method comprises an initial step of applying a thin film of processing solution to the emulsion surface. The applied film of processing, solution is carefully controlled to be sufficiently thin so as to wet substantially only the emulsion leaving the emulsion support essentially dry. Immediately after application of the processing solution, heat is applied to the emulsion through the back dry surface of the support to accelerate development of the exposed emulsion and simultaneous drying of the processing solution from the emulsion.

The term processing solution is used throughout specification and claims to designate primarily a developing solution but which for this purpose may include various additives such as emulsion stablizers and the like. A processing solution particularly applicable to this process is described and claimed in United States application Serial No. 669,601, filed by John H. Jacobs on November 29, 1957, now abandoned, and is discussed in some detail later in this specification.

We have further found that the developing procedures generally outlined above can be carried on substantially simultaneously with the exposure of the recording medium to the light beams to be recorded. In fact, the processing solution may be applied as a thin film directly after such exposure or even prior thereto, but it is desirable that exposure precede the application of heat as described.

An essential limitation to the success of the described process is the application to the recording paper of a thin film only of the processing solution as contrasted to previously conventional procedures of dipping or spraying the record so as to saturate both the emulsion and the paper with developer solution. By limiting the thickness of the applied film such that substantially only the emulsion is moistened, this film being not in excess of .0005 inch and preferably in the neighborhood of .0002 to .0003 inch thick, not only is drying facilitated but the record by reason of its dry back surface may be immediately passed over a stationary hot platen with a minimum of distortion or wrinkling thereof which could impair heat transfer from the platen into the record. Since it is necessary that the record be substantially dry before exposure to ambient light conditions for visual observation, the importance of the thin film principle in permitting very rapid drying speed is obvious. Moreover the application of heat to accelerate drying of the film has the additional advantageous effect of causing changes in the developer so that residual developer remaining in the paper is rendered relatively inert.

As a consequence of all of the factors mentioned above development is not only more rapid than any presently known process, but a comparatively stable developed record is obtained. The resultant record is comparatively stable to light but may show instability only in the presence of excess moisture.

As mentioned above, one of the advantages of the thin film technique is that we are enabled to dry the record by passing it over a stationary platen since the dry backing material slides freely and in this connection one form of apparatus of the invention capable of carrying out the process described above is illustrated in schematic elevation in the accompanying figure.

Referring to the drawing the record handling unit is enclosed in a magazine **10** having on one side a window **11** through which a light beam **12** produced in a conventional recording camera enters the magazine incident on

the record therein. The camera is illustrated schematically as a light source **13** and a modulator **14** represented as a galvanometer mirror. The camera as such forms no part of the present invention and is conventional in the process of oscillography. In the usual commercially employed oscillograph a number of channels of data may be recorded at the same time by the expedient of using a plurality of light modulators and recording the modulations responsive to separate signals applied to the respective modulators and representing a plurality of parameters to be recorded.

Typically, for example, a plurality of pressure transducers may be incorporated in various locations of a wind tunnel with their outputs separately connected to a different one of a plurality of galvanometers in a multichannel oscillograph. For the purposes of describing the invention a single galvanometer mirror **14** is shown as illustrative of the phenomena involved with the intention that this be representative of any number of separate channels of recording.

The magazine **10** houses a supply roll **16** on which an unexposed paper **17** is mounted. The record is carried over a metering roller **18** driven by conventional roller drive means (not shown) to determine the speed of travel of the recording medium through the magazine. From the metering roller the record is carried around an idling or tension roller **19** and from thence past a processing solution application **20**.

The applicator **20** as shown schematically in the drawing comprises a solution reservoir **21**, a so-called slit applicator **22** which communicates at one end with the reservoir **21** and at another end bears against the recording medium **17** as it is stretched across a mandrel **23**. Within the limits of film thickness specified above any type of solution applicator can be used. Wick-type wipers and slit applicators are satisfactory although simple roller applicators are not because it is a tendency of rollers to apply too thick a layer of fluid. As presently preferred in the practice of this invention we employ a novel slit type applicator which we have found applies an even film of solution without pumping means and which is generally insensitive to variations in record speed. The particular applicator illustrated schematically herein is described in detail and separately claimed in United States application Serial No. 712,148, filed January 30, 1958, by Michael D. Godfrey, which application issued on May 9, 1961, as Patent No. 2,983,250.

A further benefit of the thin film technique not heretofore mentioned can be appreciated by reference to the drawing. This additional benefit lies in the many-fold reduction in consumption of processing solution over that occurring in conventional developing procedures. We have noted that an entire roll of conventional photographic recording paper amounting to approximately 400 square feet can be processed with no more than 400 cubic centimeters of processing solution. The same roll processed by conventional procedure of paper dipping would not only take about 10 to 100 times the access time as emphasized above, but would involve the consumption of approximately 900 cubic centimeters of solution. A still further advantage of thin-film application of developing solution is that the developer in supply reservoir **21** remains always at full strength, there being no gradual exhaustion of developer in the process of developing a roll of paper as would be the case if the paper were immersed in the developer. At slower record speeds development is rendered self-limiting by reason of rapid drying of the thin film of developer and fogging which would otherwise occur is avoided. In other words, if a heavy layer of developer were employed the record would fog at low transport speeds because of the excessive time required to render such a heavy application inactive.

The latent image produced in the recording medium at the instant of exposure through window **11** would not be rapidly developed after application with the processing solution at the applicator **22** without further impetus. However, at this point, the record cannot be exposed to ambient light since the emulsion is highly active while it is damp with developer. Accordingly the crux of the rapid access achieved with this process is the ability as above mentioned to apply large quantities of heat relative to the amount of developer present to induce rapid development and simultaneous drying of the extremely thin film of developer at a rapid rate. This is made possible not only because a small volume of developer is involved, but because the recording paper itself has not been wet.

For this purpose the record is carried from the applicator **20** on a guide roller **24** and across a curved face **25** of a heated platen **26**. The dimensions of the platen are selected to achieve the desired degree of drying at the ranges of paper speed to be encountered and under acceptable conditions of temperature. Generally speaking we have found that the record can be dried at a temperature in excess of about 90° C. and preferably in the neighborhood of 120° C., requiring a drying time of approximately 0.4 second. This means that with a platen face of about 12 inches a paper speed of approximately 25 to 40 inches per second is permissible.

The platen **26** may be heated in conventional fashion by insert heaters (not shown). To accomplish the rapid drying desired it is necessary to transfer relatively large quantities of heat to the record. This can be accomplished by high power input to the platen or more economically can be accomplished by causing the platen to act as a heat sink storing relatively large amounts of heat developed at comparatively low power consumption during periods of inactivity, i.e., while the record roll is being changed. Any form of heated platen may be employed, there being many such adequate to apply the necessary heat to the record.

From the platen the record is passed through compression rolls **27, 28** the roller **27** being driven through a slip clutch to maintain a constant tension on the record strip between the metering roll **18** and the point of the compression rollers. Thereupon the record is discharged from the magazine through an exit slit **29**.

Using a class of processing solution particularly adapted to this method as more particularly described in the above-mentioned application of John H. Jacobs, now abandoned, the record obtained from the magazine is sufficiently stable to permit leisurely visual observation. It is the general experience that a large percentage of the records produced in the testing procedures in which these instruments are employed are of no permanent value, and once observed to evidence the conditions under investigation may be destroyed. As related to this large percentage of total record which is to be destroyed the rapid processing technique which eliminates the more time consuming treatment in stabilizing solutions has not only the advantage of quick access but further eliminates stabilization of records which have no permanent value. At the same time the record is of sufficient permanence that any segments of prolonged or permanent value may be selected and separately processed minutes, hours or days later for ultimate stabilization. At this point the time required to stabilize is of no concern since the record has already been observed and has thus served its immediate purpose.

It should be mentioned, however, that there is nothing in this developing process rendering it incompatible with stabilization of the record. If desired, an additional liquid applicator may be employed downstream from the point of heating to apply a film of stabilizer such as hypo solution to the developed and dried record. Such a procedure, however, produces additional handling problems which are not generally justified in view of the facility of later subsequent stabilization of edited portions of the developed record.

The developer for use with this process preferably has special characteristics. In particular, it must not fog the

sensitive layer at the high temperatures used for rapid development and drying, and its oxidation products should preferably be colorless. Further, the developer components of their pyrolysis and oxidation products should not react with constituents of the photosensitive layer or its support (for instance, the sensitising dyes to be found in most photographic emulsions) to form markedly colored products. This being so, and bearing in mind the diversity of the constituents which may be used in photographic media, optimum results are achieved by formulation of a particular developer to work with a desired type of photographic recording medium. The further possibility exists of evolving specially a recording medium, with a complementary developing solution, which will use the potentialities of the process to the best advantage.

We have found that a combination of 1-phenyl-3-pyrazolidone (pioneered as Phenidone by Ilford Ltd.) and chloro-1.4-dihydroxybenzene (also known as chlorquinol and chlor-hydroquinone), in association with conventional preservative, alkali, restrainer and antifoggant make a suitable developing solution, giving a low background fog with many commercially available recording papers. These recording papers are coated with a silver halide develop-out photosensitive emulsion. The use of a wetting agent may assist the rapid entry of the solution into and through the photosensitive layer, and the subsequent uniform drying on the hot platen. We have found that a commercially available alkyl naphthene sulfonate is well adapted for this use.

As an example of the type of developing solution in use, the following has been found suitable for many recording papers:

Sodium sulfite (anh.)	gm..	75
Phenidone	gm..	6
Chlor-hydroquinone	gm..	6
Caustic soda (pellets)	gm..	18
Benzotriazole	gm..	6
Potassium bromide	gm..	3
Alkyl naphthene sulfonate wetting agent (stock solution)	gm..	20
Water to	gm..	1000

It is desirable to start with water, warmed to about 50° C., to the extent of about 80% of the final volume. When all the components have been added and dissolved, preferably in the order given, the solution is made up to the final volume.

The foregoing is essentially one of the compositions discussed in greater detail in the above-mentioned application of John H. Jacobs, now abandoned.

As a significant example of effectiveness of the described process it may be compared with the operation of a presenlty available commercial oscillograph. In the present instruments paper transport speed of 2 to 100 inches-per-second or more are possible but the record is made in a detachable magazine which must be taken from the recorder to a dark room and processed in the usual manner. Under ideal circumstances the record may be available for visual examination within approximately 10–20 minutes after exposure. At the slower recording speeds and with records of approximately 250 feet in length there must be added to this time for visual observation of the initially exposed portions the time consumed in exposing the entire record. Employing the present process on the other hand any portion of the record is visible in an interval determined only by the time required to travel from exposure to discharge, this being a function of the length of record in residence between the point of exposure and the outlet window of the magazine and the paper speed involved. At recording speeds in excess of about 25 inches per second an access time of only 0.8 seconds is realized.

To facilitate an understanding of this unique photographic developing technique it has been described as applied to the field of dynamic recording. It is evident from a familiarity with the widespread efforts now being made to achieve rapid record access that this procedure represents a major advance in this field. At the same time the procedure is in no way limited in its usefulness to recording and the detailed description of such application should not be so construed.

We claim:

1. A continuous process for developing a record paper having an exposed silver halide develop-out photosensitive emulsion supported on a surface thereof which comprises continuously applying to successive portions of the emulsion a film of photographic developing solution not in excess of about 0.0005 inch in thickness and immediately thereafter, passing the paper over a heated surface with the face of the paper opposite the emulsion in contact therewith and maintaining the heated surface at a temperature in excess of approximately 90° C.

2. A recording process which comprises continuously and in serial order exposing a silver halide develop-out photosensitive recording paper to a light stimulus to be recorded, applying to the exposed photosensitive surface of the paper a film of processing solution not in excess of about 0.0005 inch in thickness whereby the paper itself is not appreciably wet, substantially immediately applying heat to the back surface of the paper to heat the emulsion to a temperature above about 90° C. for a time sufficient to dry the processing solution.

3. A recording process for recording on and developing an elongated strip of recording paper having a photosensitive silver halide emulsion on one surface thereof comprising drawing the strip of recording paper past a point of exposure to a light stimulus to be recorded, a point of application of developer solution at which point developer solution is applied evenly to the emulsion surface of the paper as it moves past said point and in an amount not to exceed .0005 inch in depth so that the paper support is not wet, and finally over a heated surface with the paper and not the emulsion in contact with the surface to accelerate development and to dry the emulsion, the recording, application of developer, and drying proceeding simultaneously in different portions of the recording paper as it is passed sequentially from one operation to the other.

4. A recording process for recording on and developing an elongated strip of recording paper having a photosensitive silver halide emulsion on one surface thereof comprising drawing the strip of recording paper past a point of exposure to a light stimulus to be recorded, a point of application of developer solution at which point developer solution is applied evenly to the emulsion surface of the paper in a layer not to exceed about .0005 inch in depth as the paper moves past said point which amount of developer solution is sufficiently small that the paper support is not wet, and finally over a heated surface with the paper and not the emulsion in contact with the surface while maintaining the temperature of the surface in excess of about 90° C. to accelerate development and to dry the emulsion, the recording, application of developer, and drying proceeding simultaneously in different portions of the recording paper as it is passed sequentially from one operation to the other.

5. A recording process which comprises continuously moving from an input to an output position recording paper having a silver halide develop-out photosensitive emulsion supported on one surface thereof, continuously exposing the emulsion surface to a light stimulus to be recorded, continuously applying a thin film of photographic developing solution not in excess of 0.0005 inch in thickness to successive portions of the emulsion surface, and after exposure continuously passing the paper over a heated surface with the paper and not the emulsion in contact with the surface to accelerate development and to dry the emulsion.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,230,089 January 18, 1966

Charles F. Robinson et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 5, after "processing" strike out the comma; column 5, lines 42 and 43, for "gm", each occurrence, read -- ml --; line 55, for "speed" read -- speeds --.

Signed and sealed this 6th day of December 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents