July 19, 1960 M. P. OSTERGAARD, JR 2,945,760

PHOTOGRAPHIC PROCESSING METHOD

Filed Jan. 8, 1957 2 Sheets-Sheet 1

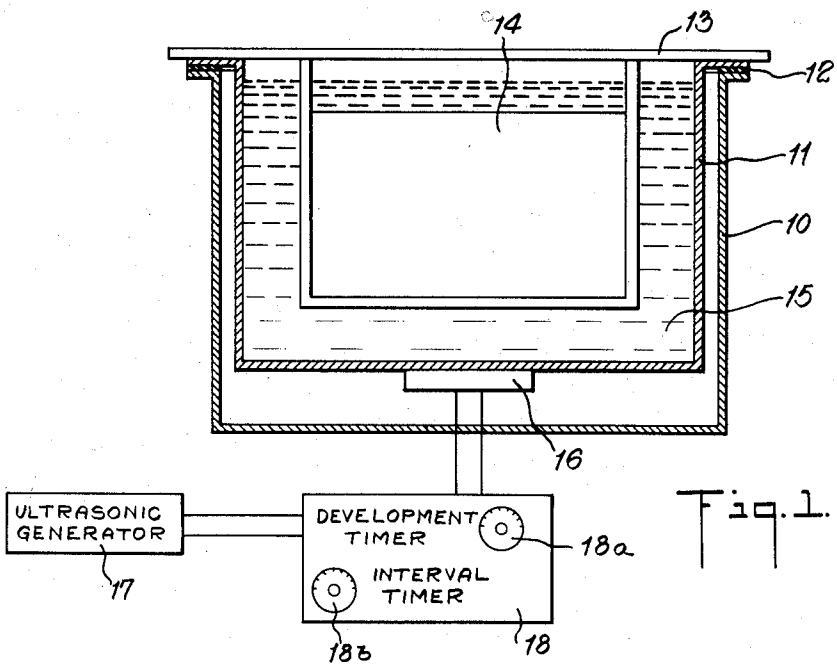


Fig. 1.

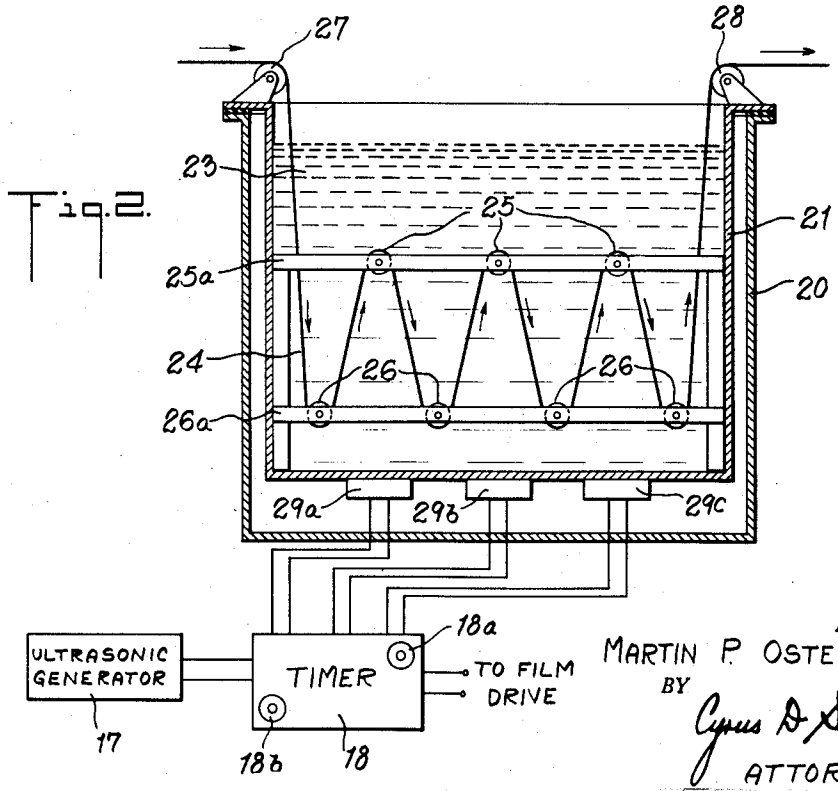


Fig. 2.

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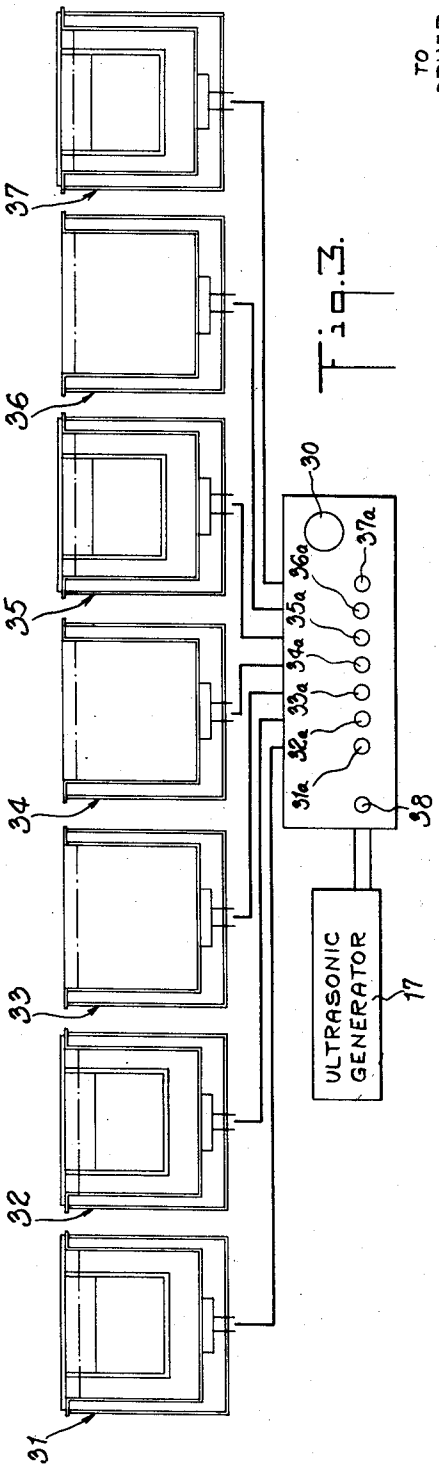


Fig. 3.

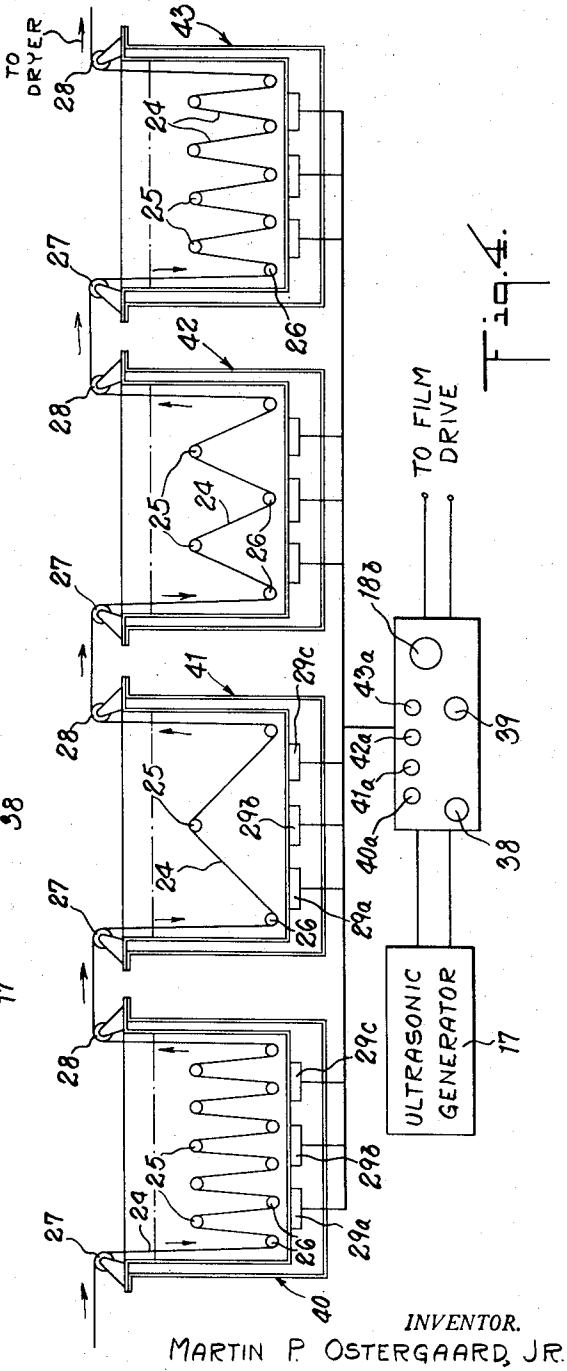


Fig. 4.

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PHOTOGRAPHIC PROCESSING METHOD

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4 Claims. (Cl. 96—48)

My invention relates to photographic processing methods and in particular to those methods wherein the processing solution is agitated by sonic or ultrasonic waves.

Practically all developing processes for developing the latent image on film, plate or other photographic material require that there be some agitation of the film, plate or other material being processed, during development. Many elaborate mechanical methods employing rockers, motors and other devices have been designed to accomplish agitation of the solution in the processing tank.

Hand agitation, which is used quite commonly in many photographic establishments, is not consistent in results due to the non-uniformity which is inherent in human beings. In addition, certain hand agitation techniques require that the film be removed from the tank during the procedure and turned 90° and reinserted in the tank. This often results in aerial fog or oxidation because the film is exposed to air during the development process.

The developer is also oxidized when the solution in a closed tank is agitated by rocking or rolling the tank by hand or other means because of the bubbles which are formed when the developer, which is agitated, comes in contact with the air in the tank. This oxidation causes the film to fog and the solution to deteriorate.

The recently introduced nitrogen-burst system of agitation, while it is an improvement over hand agitation methods, also causes oxidation of the solution with the resultant disadvantages. This is due to the fact that the developer solution bubbles because of the introduction of nitrogen into the solution under pressure. When the nitrogen-burst system is employed, the solution in the processing tank builds up a back pressure and blocks the gas ports. The net result of this action is an uneven distribution of gas entering the tank and nonuniform agitation of the solution.

It can be seen that it is necessary to agitate the processing solutions uniformly so as to obtain a homogeneous solution without oxidation or material change in temperature in order to obtain the best possible film development. Uniform agitation results in complete development of the latent image, better mixing of the chemicals in solution and better dispersal of the chemicals throughout the solution without precipitation of the chemicals out of the solution.

Accordingly, it is a principal object of my invention to provide a method for processing photographic film which produces more uniform mixing of the chemicals in solution and more uniform reaction between the developer and the film than is possible with other methods.

It is a further object of my invention to provide a photographic processing method which will produce a uniform grain pattern on the developed negative.

It is a still further object of my invention to provide a photographic processing method wherein the developed film is free of silver grain clumping and ragged edges along its sharp lines.

It is a still further object of my invention to provide a photographic processing method wherein their is an increase in film speed without increase in grain size.

It is a still further object of my invention to provide a photographic processing method wherein there is a minimum of surface bubbling of the solution.

Other objects and advantages of my invention will be apparent during the course of the following description.

I have discovered that by agitating the photographic processing solutions with ultrasonic waves I am able to obtain denser negatives than are obtained when other agitation methods are used, for the same exposure of the same scene, using the same type film and developer. The grain structure is more uniform without increase in grain size. The film is more completely developed and there is no grain clumping caused by undeveloped silver grains. There is an apparent increase in film speed of from five to ten or more times without increase in grain size when the film is exposed in light whose color temperature is equivalent to that of ordinary daylight.

The above results have been obtained, using the teachings of my invention, with ordinary panchromatic (not fine grain) film developed in standard developer and printed on standard #1 or #2 paper. In a developer which is usually considered to lose 1 F stop from the film's normal rated speed, I have been able to obtain an increase over the rated film speed of from 2 to 4 F stops.

By way of example and without limitation of the scope of my invention, I have found that excellent development results were obtained when the ultrasonic agitation frequency was 41 kc. and the agitation was applied for 5 secs. out of every minute. I have found that longer agitation times were equally good, provided the temperature of the transducer did not rise too much. When the transducer is cooled so that it does not overheat the solution, the agitation may be employed for longer time intervals.

When one quart of solution is used and there is an ultrasonic excitation frequency of 41 kc. applied for five seconds out of every minute, the temperature rise is only 1.5° F.

I have also applied ultrasonic agitation to the solution by placing the transducer in the solution itself and have found that while this method of agitation was much better than any other presently known method, it was not as good as that wherein the transducer is mounted on the outside of the tank, preferably at the bottom. There are two reasons for this action: first, the chemicals, which are not in range of the main lobe of the transducer, are not properly treated and second, the solution's temperature is not as uniform.

In the accompanying drawings, forming a part of this application, and in which like numerals are employed to designate like parts throughout the same,

Figure 1 is a front elevational view, partly diagrammatic and partly in cross section of a preferred embodiment of my invention for developing cut film, plates or film pack sheets,

Figure 2 is a front elevational view, partly diagrammatic and partly in cross section of a further embodiment of my invention for developing motion picture film,

Figure 3 is a diagrammatic view of a further embodiment of my invention for processing color cut film of the reversal type, and

Figure 4 is a diagrammatic view of a further embodiment of my invention illustrating the automatic processing of motion picture film.

In the drawings wherein, for the purpose of illustration, are shown preferred embodiments of my invention, the numeral 10 designates the outer tank which supports inner tank 11. Grommet 12 is of rubber or similar flexible material and serves to insulate 11 from any me-

chanical shock to which **10** is subjected. **12** likewise serves to insulate **10** from the ultrasonic vibrations which are applied to **11**. Hanger **13** serves to hold film **14** in solution **15**.

Transducer **16** is suitably affixed to the bottom of **11** (details not shown) and excitation is applied to **16** from ultrasonic generator **17**. Transducer **16** may be made of natural piezoelectric material, magnetostrictive material, polarized electrostrictive material or any other material which will transform the electrical energy from **17** into sonic or ultrasonic waves. I prefer to use a polarized electrostrictive material composed largely of barium titanate for the active element of transducer **16**. Timer **18** contains development timer **18***a* and interval timer **18***b*. **18***a* serves to measure the total development time and may actuate an alarm when the predetermined time has elapsed or in automatic systems may actuate a mechanism which removes the film from the developer and places it in the next solution. **18***b* serves to control the interval during which excitation is applied to **16** from **17**. **18***b* may be preset so that excitation is applied for any portion of time out of a larger segment of time. I have used 5 seconds of excitation per minute but any other excitation time segment may be preset on **18***b*. It is also within the contemplation of my invention to utilize a single unit to include the functions of both **18***a* and **18***b*.

In operation, the usual developing or other solution **15** is prepared and mixed at the proper temperature and quantity. I have found that when an excitation frequency of 41 kc. is used, it is necessary to maintain the level of **15** in **11** in multiples of 1⅜", for example: 11 inches. Cut film **14** is placed on holder **13** in the standard manner (details not shown) and **14** is placed in **15**. When **14** is so placed, **18***a* is set for the total processing time **14** is to remain in **15** and **18***b* is adjusted for excitation interval. **15** is now agitated at an ultrasonic rate for the periods during which **18***b* permits excitation to be applied to **16** from **17**. When the preset time as determined on **18***a* has elapsed, an alarm such as a buzzer or similar device is actuated (details not shown) and **14** is ready for removal from **15**. I also contemplate the use of automatic machinery with pickup fingers actuated by **18***a*, which will move the film from one processing step to the next at preset times (details not illustrated).

Figure 2 illustrates a photographic processing tank for developing or processing motion picture or similar film. Tank **21** is suspended in outer tank **20** and is mechanically insulated therefrom by grommet **22**. Rails **25***a* and **26***a* are attached in pairs in tank **21** so as to support film wheels **25** and **26** respectively. Wheels **25** and **26** are spaced so that two adjacent wheels **26** form an acute angle triangle with wheel **25** which is closest to them and two adjacent wheels **25** likewise form an acute angle triangle with wheel **26** which is closest to them. Film **24** is threaded over reel **27** and around wheels **25** and **26** as shown in the figure and out of the tank over wheel **28**. The film is moved in the direction of the arrows of Figure 2.

Timer **18** operates in the same manner as I have described for the embodiment of Figure 1 with certain additional functions. As described heretofore, timers **18***a* and **18***b* may be separate units as illustrated or may be combined in a single unit. Instead of a single transducer as shown in Figure 1, I utilize three transducers **29***a*, **29***b* and **29***c* affixed to the outer surface of the base of tank **21** and actuated by **17** under the control of **18***b*. However, a single transducer such as is illustrated in Figure 1 may also be used. Likewise, the three transducers of Figure 2 may be employed to replace the single transducer of Figure 1. Any number of transducers may be used and I have chosen one and three for illustrative purposes to demonstrate that one or more may be employed. Transducers **29***a*, **29***b* and **29***c* may be formed of any suitable material. I prefer to use polarized electrostrictive material composed largely of barium titanate. Lead zirconate, lead titanate or combinations of other such materials may also be employed. I have found that when I use an agitation frequency of 41 kc. and cylindrical transducers composed largely of barium titanate mounted to the bottom of the tank, it is best to have one transducer for each 9 square inches of tank bottom surface.

Solution **23** is prepared in the usual manner and film **24** is threaded on **27**, **26**, **25** and **28** as shown in Figure 2. **18***a* and **18***b* are set and processing begins as described above. When the time preset on **18***a* has elapsed, the film drive (not shown) is actuated and all the film **24** which has been processed is run out of **21**.

Alternatively, **24** may be in continuous motion through **23** such that its velocity and length of travel through **21** together determine the amount of processing time, as given by the formula

$$t=\frac{s}{v}$$

The distance s is a function of the number of wheels **25** and **26** over which **24** is run and the distance between the wheels.

A further alternative method utilizes a frame similar to that supporting wheels **25** and **26** which may be removed from the tank. The film **24** is threaded on **25** and **26** and the combination is placed in solution **23** and processing accomplished as described above for film **14**.

Those skilled in the art will realize that while I have described the processes above for development, the ultrasonic agitation techniques taught by my invention will work equally well in short stop, fixing, washing and other processing baths.

Figure 3 illustrates seven baths of the eleven step process for the processing of positive reversal color film. Timer **30** combines the functions of timers **18***a* and **18***b* and is preset so that excitation is applied to transducers **16** for a predetermined portion of each time segment and is so designed that no excitation is applied to any transducer **16** if the switches **31***a*, **32***a*, **33***a* etc. corresponding to tanks **31**, **32**, **33** etc., respectively, are off. **30** is designed so that the time for each tank **31** etc. is counted from the time switch **31***a* etc. is thrown and a signal associated with tank **31** etc. (not shown) is actuated when the preset time has elapsed. When switch **38** is off, no excitation is applied to any transducer **16** from **17**.

In operation, the film is placed in **31**, which contains the developer, and processed for 12 minutes and is agitated for five seconds of every minute. It is then removed from **31** and placed in **32**, which contains the rinse, where it remains for three minutes and is agitated as before. It is then placed in a rinse bath (not shown) for one minute without agitation. It is now re-exposed to light for three minutes (not shown). It is next placed in **33**, which contains color developer, for 18 minutes during which time it is agitated as described above. Now it is placed in **34**, which contains the clearing bath, for three minutes and agitation is carried on as described above. It is then placed in **35**, which contains the hardener, for five minutes and is agitated as heretofore. The wash process (not shown) is next and takes five minutes without ultrasonic agitation. The film is now placed in **36**, which contains the bleach, for eight minutes and agitation is applied. The next washing (not shown) takes three minutes and no agitation is applied. The film is now placed in **37**, which contains the fixer, for five minutes and agitation is applied. The final wash (not shown) is without agitation and consumes ten minutes.

It is understood that the above-described process is for a particular type of film and other processes lend themselves equally well to the teachings of my invention. A greater or lesser number of steps in the process may be agitated by ultrasonic waves depending on the type of film and type of processing used.

Figure 4 is an example of a continuous processing unit

for motion picture film. Switch **38** controls the application from **17** of ultrasonic excitation to transducers **29***a*, **29***b* and **29***c* of all tanks **40, 41, 42** and **43** while switches **40***a*, **41***a*, **42***a* and **43***a* control the application from **17** to transducers **29***a*, **29***b* and **29***c* of tanks **40, 41, 42** and **43** respectively. **18***b* controls the interval during which excitation is applied and **39** actuates the film drive (not shown).

The processing is started by threading a film leader as shown in the arrows of Figure 4 through tanks **40, 41, 42** and **43** to the dryer and take up reels (not shown). The film to be processed is then attached to the leader and is fed off its reel (not shown). The film is then fed through the various stages: tank **40** contains developer; tank **41** contains short stop; tank **42** contains fixer; and tank **43** contains wash. Since the velocity of the film travel is unform, I keep the time in each solution correct by adjusting the length of travel in the solutions by using more or less rollers **25** and **26** as illustrated in Figure 4. In the example illustrated, development takes 11 minutes, short stop takes three minutes, fixing takes five minutes and washing takes nine minutes. The foregoing is by way of illustration and is not intended to limit the scope of my invention since the times in various solutions may be varied as required. Ultrasonic excitation may be applied to all or some of the solutions which require agitation.

It should be understood that all types of photographic material such as roll film, cut film, strip film, plates, paper or other embodiments may be processed using the teachings of my invention and that the illustration and description of the processing of a particular type of material in the above description is by way of example and not by way of limitation and I do not wish to be limited to the specific examples and embodiments shown and described, for obvious modifications will occur to those skilled in the art without departing from the spirit of my invention or the scope of the subjoined claims.

Having thus described my invention, I claim:

1. The method of procesing exposed photographic materials which comprises placing the material to be processed in the processing solution and subjecting the solution while the material is immersed therein to alternating cycles of agitation and quiescence, the agitation being by means of ultrasonic waves having a frequency of the order of 41 kc. and being carried on for approximately 5 seconds in length out of every minute of time that the material is immersed in the solution.

2. The method of processing photographic materials as described in claim 1 which includes feeding a length of film over a plurality of rollers mounted in the processing solution and moving the film into, through and out of the solution at a predetermined rate.

3. The method of processing photographic materials as described in claim 2 which includes placing the materials sequentially in a plurality of solutions at least one of which is agitated with ultrasonic waves.

4. The method of processing photographic materials as described in claim 1 which includes feeding a length of film sequentially through a plurality of solutions over a plurality of rollers mounted in each of said processing solutions and moving the film into, through and out of said solutions at a predetermined rate, at least one of said solutions being agitated with said ultrasonic waves having a frequency of the order of 41 kc.

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