April 21, 1959 LE ROY J. LEISHMAN 2,883,546

CIRCUITS FOR X-RAY SPOT FILM DEVICES

Filed Nov. 30, 1955 3 Sheets-Sheet 1

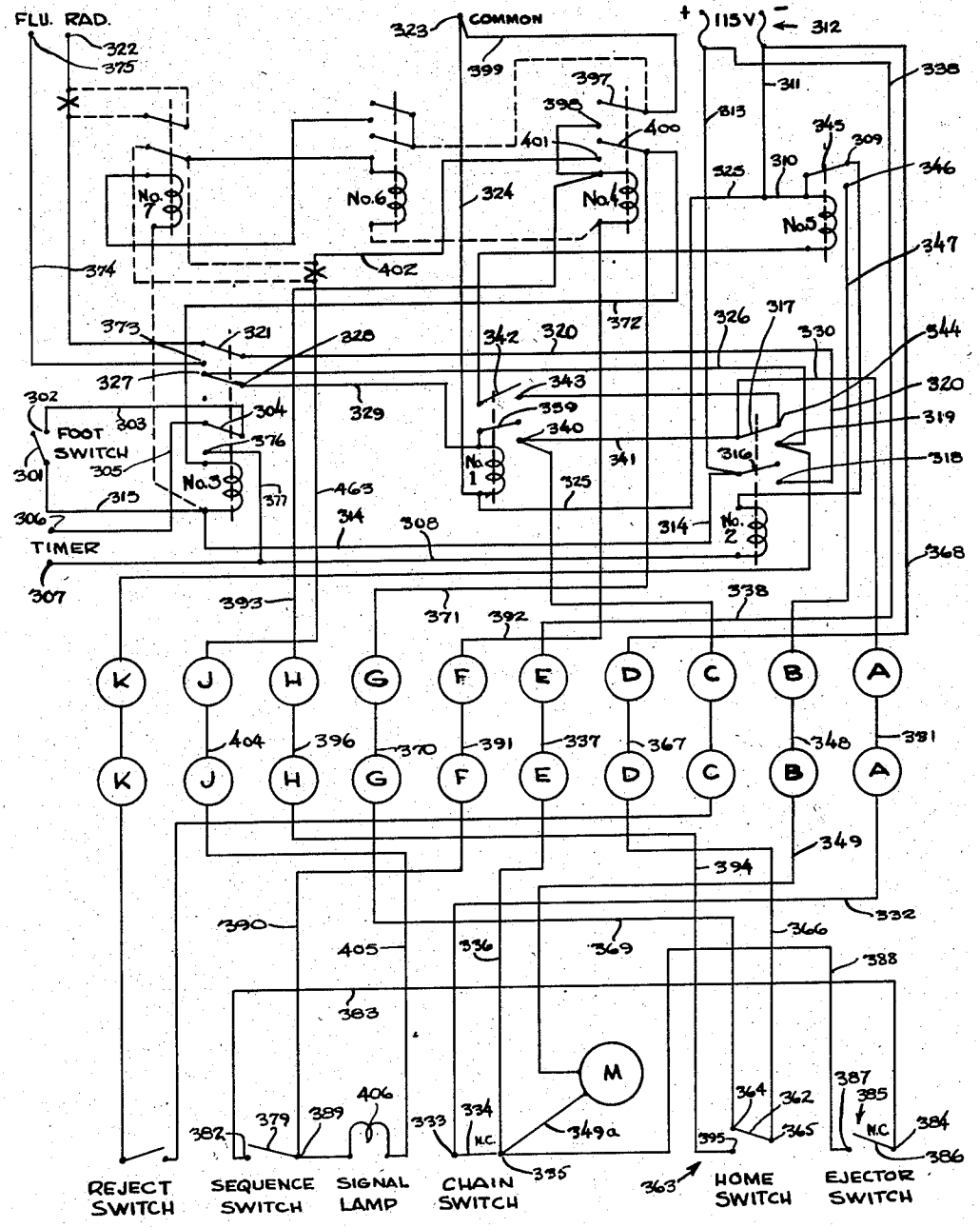


FIG. 1

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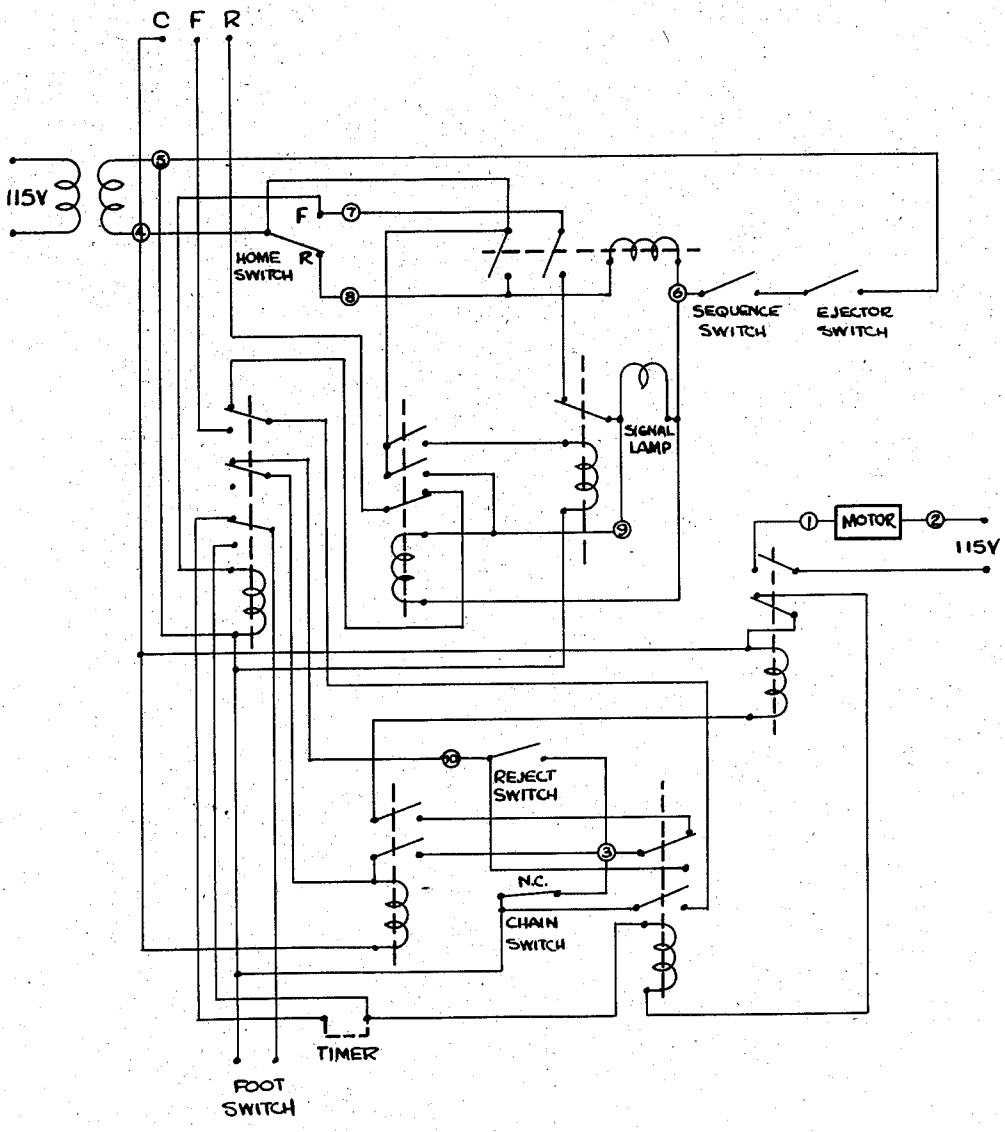


FIG. 2

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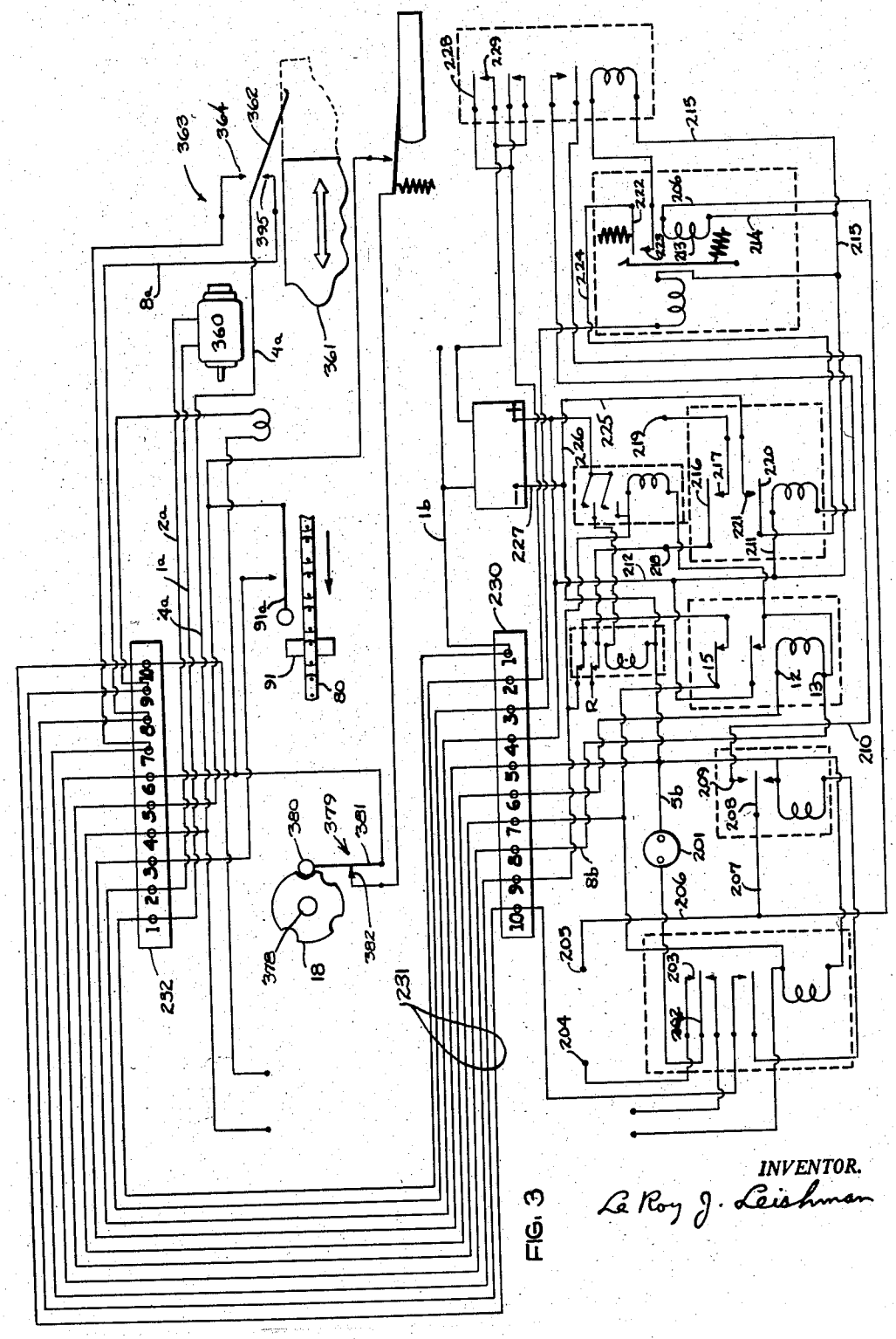


FIG. 3

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CIRCUITS FOR X-RAY SPOT FILM DEVICES

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Application November 30, 1955, Serial No. 550,101

3 Claims. (Cl. 250—66)

The invention herein described pertains to X-ray equipment and more particularly to circuits for use in connection with what are known in the profession and industry as spot film devices.

Spot film devices may be divided roughly into three groups: those that are entirely manually operated; those in which the carriage that brings the cassette into the proper positions for the various exposures is moved from the rest position outside the X-ray beam to such exposure positions and then back again by means of a motor; and those in which the carriage is brought from the rest position by means of a spring but returned by means of a motor. Some features of the present invention may be applied to any of these different types of spot film devices, but many of them are primarily concerned with the last mentioned variety.

In connection with the latter type of spot film device, one of the objects of the present invention is to provide simple means whereby the motor that returns the carriage to its rest position will be automatically actuated upon the completion of the exposure regardless of whether such exposure is timed by the operator himself, by an automatic timer that determines the interval of the exposure according to an advance setting, or by a photo timer.

Another object of the invention is to provide means for automatically stopping the motor after the carriage returns.

Another object is to provide electrical means to make it impossible to turn on the X-rays or to shut off the motor after the exposure has been completed and the carriage is on its way to its home position.

Another object is to provide a simple circuit arrangement whereby the manual closing of a switch will return the carriage to its home position without turning on the X-rays.

It is a further object to incorporate in the circuitry provisions for automatically switching to the circuits for radiography when the carriage leaves its home position and to switch back again to fluoroscopy when the carriage returns to its home or rest position.

An additional object is to make it impossible to turn on the motor by the operation of the aforementioned reject switch or the switch that initiates the exposure after the carriage has returned to its home or rest position.

Additional objects that are applicable to all types of spot film devices include the provision of means for turning on a warning lamp or signal light when the last exposure in any given series has been made. There are various spot film devices upon the market in which double exposures are prevented by locking the carriage in its home position after the completion of the last exposure in the series so that the carriage will not move into the field even though an extra exposure is attempted. While such an arrangement effectively prevents a double exposure, it nevertheless permits the radiologist who has forgotten that he has made the last exposure in a series to waste considerable time waiting for a situation to arise within the patient that might have diagnostic significance so that he can make another exposure. In such an event, the exposure that he attempts is prevented, but obviously considerable time is lost.

Another object of the present invention is the provision of means whereby the warning light is turned off automatically upon the removal of the cassette or the adjusting of the device for a new series of exposures.

Still another object of the invention is the provision of means whereby a double exposure is prevented even though the radiologist may not heed the warning signal.

Yet other objects will appear as the specification proceeds.

In the drawings:

Fig. 1 is a wiring diagram showing the circuit arrangements that I presently prefer, the spot film device itself being shown separately from the operating relays. Two of the relays in the circuit of Fig. 1 are optional, the wires that connect these relays in circuit being shown in broken lines, and the conductors that may be omitted when these optional relays are included are crossed out with a dark cross.

Fig. 2 is a schematic diagram of the same circuits shown in Fig. 1, with the exception that this circuit employs a different voltage for the relays and the signal lamp than for the motor.

Fig. 3 is a modified circuit in which two different voltages are also employed for the relays and signal lamp than for the motor. Slight alterations in this circuit, however, make it possible to operate all circuits on the same voltage.

The circuits shown in the drawings and that will be hereinafter described are particularly adaptable to the mechanism shown and described in the co-pending patent application Serial No. 549,773, now Patent No. 2,811,648.

The operation of the circuits of Fig. 1 will probably be best understood if we describe the circuits in the order in which they are operated for their intended purposes.

It will be assumed that the carriage is in the proper position for an exposure and that the radiologist is ready to initiate such exposure. This is done by the closing of an appropriate switch which may be operated either by the hand or by the foot or automatically closed when the carriage reaches the position that it is to occupy when any given exposure is to be made or after a predetermined interval has elapsed following the departure of the carriage from its home or rest position.

The operation of the foot switch 301 closes a circuit to contact 302 from whence the current flows through wire 303 to the armature 304, relay No. 3, and thence to wire 305 and the terminal 306 of the timer. It is to be assumed that the timer circuit is closed and will not open until sufficient time has passed to complete the exposure as determined either by the photo timer or such other timing device as may be employed. While the timer circuit is closed, the current flows to contact 307, through wire 308, the coil of relay No. 2 and then to contact 309 of relay No. 5. This relay will at this time be open, and its normally closed contacts will thus permit the current to flow through wires 310 and 311 to what we shall designate as the negative side of a source of electrical potential 312. The circuit from the positive side of this source of current is completed back to the movable contact 301 of the foot switch by means of conductors 313, 314 and 315. Inasmuch as the operation of the foot switch has thus completed the circuit through the coil of relay No. 2 the armatures 316 and 317 of this relay will move from the positions indicated in the figure to the lower contacts 318 and 319 respectively.

Since contact 316 is connected to the positive side of the current source by conductor 313, the current will flow from armature 316 and contact 318 through conductor

320, armature 321 of relay No. 3 and thence to terminal 322, which is assumed to be connected to a suitable relay for closing the high potential circuits to initiate the X-ray exposure. The other side of the coil of the relay that controls the radiographic exposures is connected to terminal 323 which is a common terminal provided also for the coil of such relay as may be used for turning on the X-rays during fluoroscopy. The common terminal 323 is connected by wires 324, 325 and 311 to the negative side of the current source 312.

The closing of relay No. 2, as previously mentioned, brought armature 317 into engagement with contact 319. The circuit thus closed will be traced from this point. From contact 319 the current flows through conductor 326 to contact 327 of the central section of relay No. 3. Inasmuch as this relay will not at this time be energized, the current will flow from contact 327 through armature 328 and conductor 329 to the coil of relay No. 1. The other side of this coil is provided with a negative potential through conductors 325 and 311 as previously explained. Current is provided to the armature 317, from whence the instant circuit was originally traced, through conductor 330, terminal A of the relay panel, cable conductor 331, terminal A of the spot film device and thence through conductor 332 to terminal 333 of a normally closed switch 334. This switch is operated by means of a dog or projection on the chain that returns the carriage from the position that it occupied when the exposure was made, to the home position. Such a chain and dog are shown in co-pending application Serial No. 549,774, but it is indicated diagrammatically in Fig. 3 of the present application where a chain 80 is shown with a dog or projection 91 that engages arm 91*a* to close a contact. In the embodiment with which we are at present concerned, however, this switch is normally closed and is opened by the passing of the dog 91 in the direction indicated by the arrow, whereas in the embodiment in Fig. 3, the passing of dog 91 results in the closing of the switch.

Getting back to Fig. 1, it will be seen that the normally closed switch 334 closes a circuit with contact 335, which is connected by conductor 336 to terminal E of the spot film device. This terminal is in turn connected to cable conductor 337 and terminal E of the relay panel, and thence by conductor 338 to the positive side of the source of current supply. The circuit just traced, of course, energized the coil of relay No. 1. This brought armature 339 of relay No. 1 into engagement with contact 340 of this relay. This contact is connected through conductor 341 to terminal 316 of relay No. 2. It has already been shown that this terminal is provided with a positive potential whenever the normally closed chain switch 334 is in its normal position. The making of contact between armature 339 and contact 340 thus provides a positive potential to one side of the coil of relay No. 1. This coil was originally energized, as previously explained, by the closing of relay No. 1 upon the operation of the foot switch. When relay No. 1 is energized, the armature 339 and contact 340 thus act to set up this relay and lock it electrically in circuit.

The operation of relay No. 1 also brings armature 342 into engagement with contact 343. This completes the circuit between the coil of relay No. 5 and contact 344 of relay No. 2. Inasmuch as the armature 317 is disengaged from contact 344 when this relay No. 2 is energized—which is the condition at the time at which we are dealing—the closing of contact between armature 342 and contact 343 of relay No. 1 serves merely to set up this connection for future use. When the timer breaks the circuit to the coil of relay No. 2, armature 316 parts engagement with contact 318, thus breaking the circuit that was previously described to terminal 322 through which the radiographic relay is energized. The exposure is thus terminated.

The de-energizing of relay No. 2 upon the breaking of the circuit by the timer results also in armature 317 breaking engagement with contact 319 and re-engaging contacts 344. The breaking of engagement with contact 319 opens the circuit through which relay No. 1 was originally energized; but as already explained, the initial energizing of relay No. 1 locks this relay in circuit irrespective of the opening of the portion of the circuit completed through relay No. 2. The engagement of armature 317 with contact 344, however, completes a circuit from this armature, to which a positive potential has previously been traced through contact 343 and armature 342 of relay No. 1 to one side of the coil of relay No. 5. The other side of this coil is connected to the negative side of the current source by conductors 310 and 311. The energizing of relay No. 5 accomplishes two things. It starts the motor and also opens the circuit to the coil of relay No. 2, thus making it impossible to turn on X-rays of any sort.

The engagement of arm 345 with contact 346 completes a circuit from the negative side of the current source through conductors 347 to terminal B of the relay panel and thence through cable conductor 348 to the spot film device terminal B. This terminal is connected by conductor 349*a* to one side of the motor M. The other side of this motor is connected by conductor 349*a* to terminal 335. The connection of this terminal to the positive side of the current source has previously been traced. The operation of relay No. 5 thus serves to turn on the motor, and, as previously mentioned, to make it impossible to turn on X-rays while the motor is running.

The motor continues to run until the chain switch 334 is operated by the previously mentioned dog on the chain that returns the carriage to its home or rest position. When contact 334 opens, the current is broken through conductor 332 and other connected conductors to terminal 340 that originally supplied the current upon the engagement therewith or armature 339 to lock the coil of relay No. 1 in its energized condition. The opening of the normally closed chain switch thus serves to de-energize coil No. 1. Inasmuch as this causes armature 342 to part company with contact 343, the coil of relay No. 5 is also de-energized. This stops the motor and reconnects armature 345 with contact 309 and restores the normal negative voltage to one side of the coil No. 2, permitting it to operate in response to the foot switch in the manner previously described.

The previously described energizing of the motor 360, shown in Fig. 3, resulted in the return of the carriage 361, indicated by a fragment thereof in Fig. 3. When the carriage reaches the extreme right position shown in dotted lines in this figure, it engages the arm 362 of the switch 363, causing it to engage contact 364. Returning now to Fig. 1, we shall trace the circuits energized by such movement of this switch. Terminal 365 of this switch is provided with a negative potential through conductors 366, terminal D of the spot film device, the cable conductor 367, terminal D of the relay panel and conductor 368 which is directly connected to the negative side of the current supply. The negative potential thus supplied to contact 364 when switch 363 is in the position that it occupies when the carriage is in its home position, is carried by conductor 369 to terminal G of the spot film device. This, in turn, is connected by cable conductor 370, terminal G of the relay panel, conductor 371 and conductor 372 to one side of the coil of relay No. 3. The opposite side of this coil is connected to the positive side of the current source by conductors 341 and 313. The return of the carriage to its home or rest position thus results in the energizing of coil No. 3. When this takes place, armature 321 of this relay engages contact 373. This contact is connected by conductor 374 to terminal 375, which carries any impulses that may proceed through the associated conductors to the coil of whatever relay may be used to close the high potential currents for fluoroscopy.

The energizing of the coil of relay No. 3 moves arma-

ture 328 away from contact 327, thus opening this circuit and eliminating any possibility of the initial energizing of coil No. 1, which, as previously mentioned, sets up a portion of the circuits that actuate the motor.

The energizing of the coil of relay No. 3 also brings armature 304 to its lower position where it engages contact 376. This serves to connect the foot switch directly to the coil of relay No. 2 through conductors 377 and 308 rather than through the timer. The operation of the foot switch will thus operate relay No. 2 in the manner hereinbefore described. The fact that armature 321 of relay No. 3 is now in engagement with contact 373, results in circuits being closed for fluoroscopy rather than for radiography.

As mentioned in the objects at the beginning of this specification, one of the purposes of this invention is to provide means whereby a visible signal is given when the last exposure in any series of radiographs has been completed. This is brought about through the instrumentality of relay No. 4. Relays Nos. 6 and 7, which are optional, serve to prevent a double exposure in case the visible signal is ignored.

Many spot film devices are provided with means for pre-setting the apparatus at the beginning of any desired series of radiographs so that the carriage will be brought to the required position for the first exposure. After each exposure a programming means advances so that the carriage is brought to the proper position required for each succeeding exposure. One mechanism whereby this is done is shown in co-pending applications, Serial No. 413,181, now Patent No. 2,817,766, and Serial No. 549,775. I provide a shaft 378 that is operatively connected to a knob or other means whereby the apparatus is placed in the required positions and conditions for the first exposure in any series. This shaft changes its position, as fully described in the said co-pending applications. For the purpose of the present disclosure, it is sufficient to those skilled in the art to know that shaft 378 is operatively connected to such mechanism. After the termination of the last exposure in any given series, a switch 379 automatically closes. This may be accomplished by any appropriate camming means, such as the cam 18 shown in Fig. 3, which is provided with indentations into which the follower 380 drops when the wheel or cam 18 is in the angular position that it occupies when the last exposure in a given series is being made. It will be observed in this figure that arm 381 of this switch engages contact 382 of the switch 379.

Going back to Fig. 1, the armature of sequence switch 379 is shown diagrammatically in engagement with contact 382, and the further operations of the circuits connected therewith will be described in connection with Fig. 1. It will be observed that contact 382 is connected by conductor 383 to terminal 384 of the ejector switch 385. This switch is normally closed, but opens upon operation of the ejector that removes the cassettes used in spot film devices from the carriages that transport them to and from the rest position. When switch 385 is in its normally closed position, its armature 386 engages contact 387. This in turn is connected by means of conductor 388 to terminal 335. It has previously been explained that terminal 335 is connected to the positive side of the current source through associated conductors. In view of the connections just described, it will be seen that when the ejector switch 385 is in its normally closed position and when the sequence switch is also closed that negative potential will be carried from contact 389 through conductor 390 to terminal F of the spot film device. Current accordingly will pass through the cable conductor 391, the relay terminal F and conductor 392 to one side of relay No. 4. The other side of this coil is connected by conductor 393 to terminal H of the relay panel which in turn is connected to cable conductor 396, spot film device terminal H and conductor 394 to terminal 395 of the single pole double throw switch 363. When the carriage leaves its home position, the armature 362 of the home switch immediately engages contact 395 and closes a circuit to this contact, which remains closed until the carriage again returns to its home position. It has already been explained that the armature 362 of the home position switch is supplied with a negative potential. Accordingly, when the carriage leaves its home position this negative potential is carried through conductor 394 and the connected conductors to complete the circuit to the coil of relay No. 4. When this relay closes, armature 397 engages contact 398 in order to lock the coil of this relay in an energized condition through conductor 399 and terminal 323, which has already been described as being connected to the negative side of the current supply. Relay No. 4 thus remains set up even after the carriage returns to its home position and opens the connection between armature 362 and contact 395 of the home position switch.

The energizing of relay No. 4 brings armature 400 into engagement with contact 401. If the optional relays Nos. 6 and 7 are not employed, the engagement of armature 400 with contact 401 completes a circuit through conductors 402 and 403 to terminal J of the relay panel which in turn is connected by the cable conductor 404 to the spot film terminal J. This is connected by wire 405 to one side of the signal lamp 406. When the remainder of the circuit is completed by the return of the carriage to its home position after the last exposure has been made, the signal lamp will be energized and will remain so until either the ejector switch is operated or the sequence switch is opened by the turning of the shaft to which cam 18 is attached.

The circuits just described are shown schematically and in perhaps simpler form in Fig. 2.

Fig. 3 discloses other modifications.

Still other alterations and modifications may be made from the illustrative embodiments hereinbefore described, and various substitutions and transpositions may be made in connection with the elements set forth in the appended claims, or in the combinations shown and described, without departing from the broad spirit of my invention.

My claims are:

1. In an X-ray spot film device, a combination including: a sequence wheel that advances angularly from preselected angular positions that are each individual to the first exposure in a different series of exposures to other angular positions that are each individual to the last exposure in the series of which such last exposure is a part; a first electrical switch operatively connected to said wheel to close when said wheel is in any of said other angular positions; a carriage for supporting and transporting a cassette between a home positions and the various positions that such cassette must occupy for the making of various exposures; a second switch that opens upon operation of a device that ejects such cassette as may then be supported by said carriage; a relay having an operating coil one side of which is connected to one side of a source of electrical energy when said first and second switches are both closed; a single pole double throw switch that electrically connects the other side of said coil to the other side of said source of electrical energy when said carriage is not in said home position; a first pair of contacts associated with said relay which close upon the energizing of said coil and connect said other side of said coil to said other side of said source of electrical energy; said relay having a second pair of contacts that close in response to the energizing of said coil; and a signal lamp; said single pole double throw switch acting to energize said signal lamp when said carriage is in said home position while said second pair of contacts and said first and second switches are all closed.

2. In an X-ray spot film device embodying a carriage for supporting and transporting a cassette between a home position and the various positions that such

cassette must occupy for the making of various exposures, a combination including: a sequence wheel that advances angularly from preselected angular positions that are each individual to the first exposure in a different series of exposures to other angular positions that are each individual to the last exposure in the series of which such last exposure is a part; a first electrical switch that closes when said wheel is in any of said other angular positions; a second switch that opens upon operation of a device that ejects such cassette as may then be supported by said carriage; a relay having an operating coil one side of which is connected to one side of a source of electrical energy when said first and second switches are both closed; a single pole double throw switch that electrically connects the other side of said coil to the other side of said source of electrical energy when said carriage is not in said home position; a first pair of contacts associated with said relay which close upon the energizing of said coil and connect said other side of said coil to said other side of said source of electrical energy; said relay having a second pair of contacts that close in response to the energizing of said coil; and a signal lamp; said single pole double throw switch acting to energize said signal lamp when said carriage is in said home position while said second pair of contacts and said first and second switches are all closed.

3. In an X-ray spot film device embodying a carriage for supporting and transporting a cassette between a home position and the various positions that such cassette must occupy for the making of various exposures, a combination including: a sequence wheel that advances angularly from preselected angular positions that are each individual to the first exposure in a different series of exposures to other angular positions that are each individual to the last exposure in the series of which such last exposure is a part; a first electrical switch that closes when said wheel is in any of said other angular positions; a second switch that opens upon operation of a device that ejects such cassette as may then be supported by said carriage; a first relay having an operating coil one side of which is connected to one side of a source of

electrical energy when said first and second switches are both closed; a single pole double throw switch that electrically connects the other side of the coil of said first relay to the other side of said source of electrical energy when said carriage is not in said home position; a first pair of contacts associated with said first relay which close upon the energizing of said coil and connect said other side of said coil to said other side of said source of electrical energy; said first relay having a second pair of contacts that close in response to the energizing of the coil of said first relay; a second relay having a first and a second pair of normally closed contacts; a third relay having a first and second pair of normally open contacts; the closing of the second pair of contacts of said first relay acting to energize said third relay when the first pair of contacts of said second relay are closed; a signal lamp; said single pole double throw switch acting to close a circuit to one side of said lamp when said carriage is in said home position while said second pair of contacts of said first relay, the first pair of contacts of said second relay, and said first and second switches are all closed; the first pair of contacts of said third relay acting when closed to energize said third relay when the first pair of contacts of said second relay are open and to complete the circuit connection to said lamp that was previously made through the first pair of contacts of said second relay; the second pair of contacts of said third relay acting to make the circuit connection to the second relay that was previously made when the first pair of normally closed contacts of said second relay remained closed; and the second pair of normally closed contacts of said second relay acting when said second relay is energized to open the circuit through which the signals for radiography are transmitted.

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