Film-Tech

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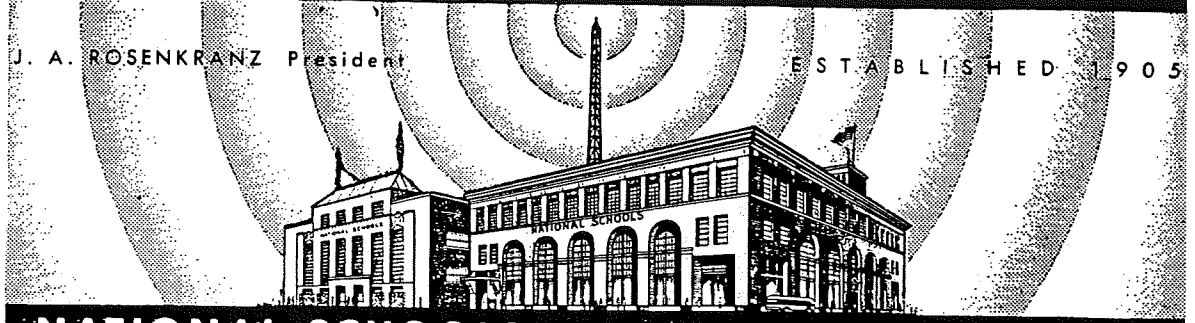
Practical Technical Training In
RADIO·TELEVISION
AND ALLIED ELECTRONICS

J. A. ROSENKRANZ President ESTABLISHED 1905



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SOUND PICTURES

LESSON NO. SP - 2

SOUND RECORDING ON FILM

IN THIS LESSON WE ARE GOING TO DISCUSS A TYPE OF SOUND RECORDING, WHICH IS ENTIRELY DIFFERENT FROM THE DISC METHOD ABOUT WHICH YOU LEARNED IN THE PRECEDING LESSON. NOW, WE ARE GOING TO DISCUSS SYSTEMS IN WHICH THE SOUND EFFECTS ARE RECORDED ON A STRIP OF PHOTOGRAPHIC FILM, THE SAME AS THE PICTURE ITSELF, SO THAT NO DISC RECORD IS REQUIRED.

WE GENERALLY REFER TO THIS METHOD OF SOUND RECORDING AS "SOUND-ON-FILM" OR SIMPLY "FILM RECORDING". TWO POPULAR SYSTEMS EMPLOYING THIS METHOD ARE THE WESTERN ELECTRIC ("MOVIETONE") AND THE R.C.A. ("PHOTOPHONE"). ALTHOUGH BOTH OF THESE SYSTEMS RECORD THE SOUND ON FILM, YET THE PROCESSES INVOLVED BY EACH ARE DIFFERENT. THEREFORE, THESE TWO SYSTEMS WILL BE DESCRIBED SEPARATELY IN THIS LESSON.

HOWEVER, BEFORE GOING INTO THE DETAILED DISCUSSION OF EITHER OF THESE SYSTEMS, IT IS ADVISABLE THAT YOU FIRST BECOME FAMILIAR WITH A UNIT, WITHOUT WHICH NEITHER SOUND-ON-FILM NOR TELEVISION WOULD BE POSSIBLE. THE UNIT IN QUESTION IS THE PHOTO-ELECTRIC CELL. BY STUDYING ITS CONSTRUCTION AND OPERATION AT THE BEGINNING OF THIS LESSON, YOU WILL READILY UNDERSTAND ITS APPLICATION TO SOUND PICTURES AS WE PROGRESS WITH THE INSTRUCTION.

FIG. 1
STUDENTS WORKING ON PROJECTOR

PHOTO-ELECTRIC CELLS

TWO DIFFERENT TYPES OF PHOTO-ELECTRIC CELLS ARE SHOWN IN FIG.2 AND THE SYMBOL FOR THE "PHOTO-CELL", AS IT IS FREQUENTLY CALLED, IS SHOWN IN THE LOWER PORTION OF FIG.2. THE CELL AT THE LEFT IS KNOWN AS THE "VISITRON" PHOTO-ELECTRIC CELL AND IN THIS CASE, THE CATHODE CONSISTS OF A CONCAVE METAL SURFACE UPON WHICH A LIGHT-SENSITIVE MATERIAL IS DEPOSITED AND THE ANODE IS IN THE FORM OF A CENTRALLY LOCATED WIRE. BOTH OF THESE ELEMENTS ARE SEALED WITHIN A GLASS BULB, WHICH IN SOME CASES IS EVACUATED WHILE IN OTHER CASES BEING FILLED WITH SOME INERT GAS, SUCH AS HELIUM, ARGON, OR NEON AT LOW PRESSURE. CELLS OF THE LATTER TYPE ARE GENERALLY REFERRED TO AS BEING OF THE GAS-FILLED TYPE. FROM ITS OUTER APPEARANCE, THIS PHOTO-CELL SOMEWHAT RESEMBLES A RADIO TUBE.

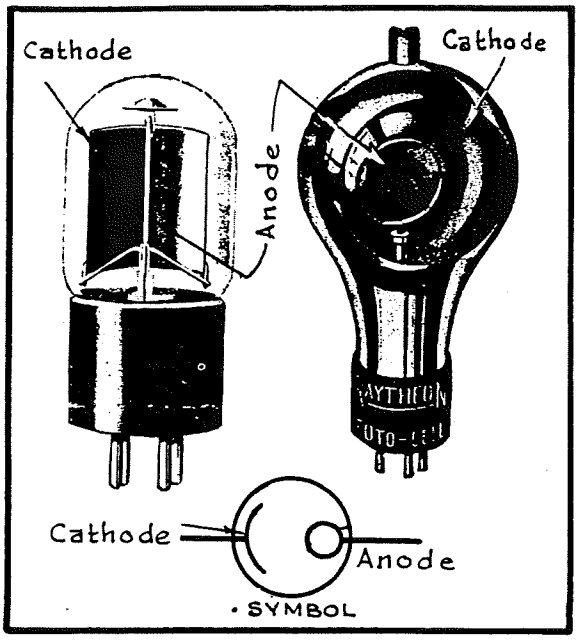

FIG. 2
Photo Electric Cells.

THE PHOTO-CELL AT THE RIGHT OF FIG.2 IS A "RAYTHEON" AND IN THIS CASE, THE SHAPE OF THE GLASS BULB IS DIFFERENT AND THE ANODE TAKES THE FORM OF A METALLIC RING. THE ACTIVE OR LIGHT-SENSITIVE MATERIAL IN THIS RAYTHEON PHOTO-CELL IS APPLIED TO A METALLIC COATING ON THE INNER SURFACE OF THE GLASS BULB, THUS FORMING THE CATHODE.

A CIRCULAR PORTION OF THE GLASS, HOWEVER, IS LEFT CLEAR AND THIS IS KNOWN AS THE "WINDOW" AND THROUGH THIS TRANSPARENT PORTION, WE PASS A BEAM OF LIGHT FROM THE OUTSIDE SOURCE. SO MUCH FOR THE CONSTRUCTION OF PHOTO-CELLS -- NOW LET US CONTINUE WITH THE DISCUSSION CONCERNING THEIR OPERATION.

OPERATION OF THE PHOTO-ELECTRIC CELL

IN FIG.3 WE HAVE A FUNDAMENTAL PHOTO-ELECTRIC CELL CIRCUIT AND AS YOU WILL NOTE, THE POSITIVE END OF A BATTERY IS CONNECTED TO THE ANODE OF THE PHOTO-CELL THROUGH A MICROAMMETER AND RESISTOR WHILE THE NEGATIVE END OF THE BATTERY IS CONNECTED TO THE CATHODE SURFACE OF THE CELL. THE ANODE OF THE CELL NOW CORRESPONDS TO THE PLATE OF AN ORDINARY RADIO TUBE AND THE CATHODE TAKES THE PLACE OF THE FILAMENT OR CATHODE OF A RADIO TUBE.

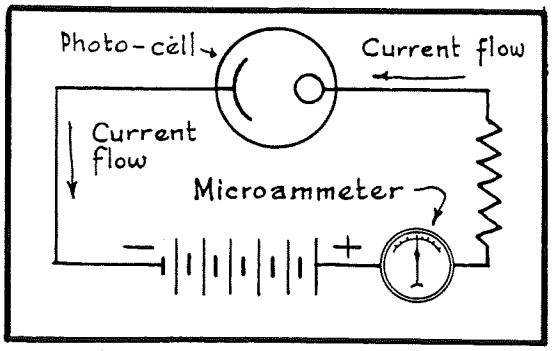

FIG. 3
A Circuit for the Photo-cell.

IN ALL TYPES OF RADIO TUBES, WE DEPEND UPON HEAT, IN ORDER TO OBTAIN AN ELECTRON EMISSION AND THE HEAT IS FURNISHED BY A FILAMENT CURRENT. IN THE CASE OF THE PHOTO-CELL, WE HAVE NO HEATING ELEMENT BUT IN PLACE OF THIS, ELECTRONS ARE EMITTED FROM THE CATHODE DUE TO THE EFFECTS OF LIGHT RAYS STRIKING THE LIGHT-SENSITIVE SURFACE OF THE CATHODE.

MANY SUBSTANCES WILL EMIT ELECTRONS WHEN PLACED UNDER THE INFLUENCE OF LIGHT BUT CERTAIN SUBSTANCES WILL EMIT MANY MORE ELECTRONS UNDER THESE CONDITIONS THAN OTHERS. ALKALI METALS OR ALKALI-METAL HYDRIDES ARE QUITE SENSITIVE TO LIGHT RAYS AND AMONG THE MOST COMMONLY USED ALKALI-METAL HYDRIDES FOR PHOTO-CELL PURPOSES ARE SODIUM HYDRIDE, POTASSIUM HYDRIDE AND CAESIUM HYDRIDE. THERE ARE STILL OTHER SUBSTANCES, WHICH EXHIBIT PRONOUNCED EFFECTS WHEN SUBJECTED TO LIGHT RAYS BUT THOSE MENTIONED ARE THE MOST EFFECTIVE MATERIALS, WHICH HAVE BEEN FOUND UP TO THE PRESENT TIME. WE SPEAK OF THESE SUBSTANCES AS BEING "LIGHT SENSITIVE".

SHOULD THE PHOTO-CELL OF FIG.3 BE PLACED IN TOTAL DARKNESS, THEN THE MICROAMMETER WOULD INDICATE NO CURRENT FLOW BECAUSE NO ELECTRONS ARE BEING EMITTED FROM THE CATHODE SURFACE. NOW IF A BEAM OF LIGHT WERE TO BE DIRECTED TO THE LIGHT-SENSITIVE SURFACE OF THE CATHODE, A STREAM OF ELECTRONS WILL BE EMITTED FROM THIS SURFACE AND SINCE THE ANODE IS AT A POSITIVE POTENTIAL, DUE TO THE BATTERY CONNECTION, IT WILL ATTRACT THE EMITTED ELECTRONS. THE RESULT IS THAT WE HAVE A STREAM OF ELECTRONS AT THIS TIME FLOWING FROM THE CATHODE OVER TO THE ANODE AND THEREFORE CURRENT WILL FLOW THROUGH THE SYSTEM AS INDICATED, THE SAME AS PLATE CURRENT FLOWS THROUGH THE CONVENTIONAL RADIO TUBE.

IF THE LIGHT BEAM IS INTENSIFIED, THEN THERE WILL BE AN INCREASED ELECTRON EMISSION FROM THE CATHODE, ACCOMPANIED WITH A CORRESPONDING INCREASE IN THE SO CALLED "PLATE CURRENT" OR PHOTO-CELL CURRENT. THUS IT IS SEEN THAT THE CURRENT FLOW WILL VARY AS THE INTENSITY OF LIGHT, WHICH IS FOCUSED UPON THE PHOTO-CELL VARIES.

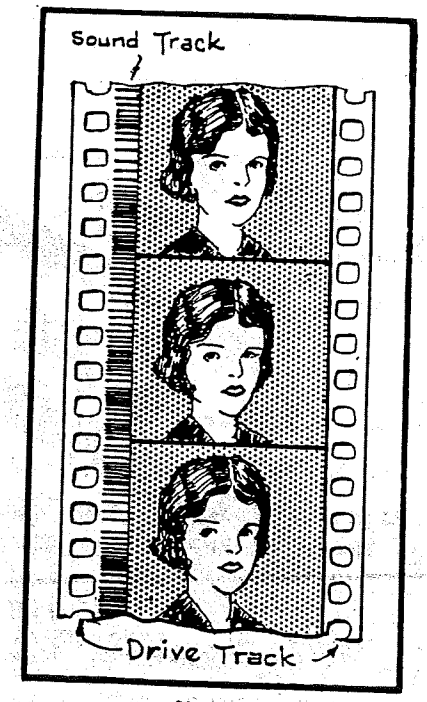

FIG. 4
Section of a Film as Used in the Movietone System.

THE PHOTO-CELL CAN BE COMPARED VERY NICELY TO A MICROPHONE, FORTHE MICROPHONE CHANGES AIR PRESSURE VARIATIONS INTO ELECTRICAL CURRENT VARIATIONS OF CORRESPONDING FREQUENCY, WHEREAS THE PHOTO-CELL CHANGES LIGHT VARIATIONS INTO ELECTRICAL CURRENT VARIATIONS OF CORRESPONDING FREQUENCY. THE CURRENT THROUGH THE PHOTO-CELL IS SO SMALL THAT IT IS MEASURED IN MICROAMPERES (MILLIONTHS OF AN AMPERE).

GAS-FILLED PHOTO-CELLS ARE MORE SENSITIVE THAN THE VACUUM TYPE. THE REASON FOR THIS IS THAT THE PHOTO ELECTRONS IONIZE THE INERT GAS IN THEIR PASSAGE FROM THE CATHODE SURFACE OVER TO THE ANODE. THAT IS, THE PHOTOELECTRONS FLOW FROM THE CATHODE OVER THE ANODE AT SUCH A TREMENDOUS

VELOCITY, THAT WHEN THEY COLLIDE WITH MOLECULES OF THE INERT GAS, THEY BREAK THESE MOLECULES UP INTO THE ELECTRONS AND PROTONS OF WHICH THEY ARE COMPOSED. WE CALL THIS ACTION "IONIZATION BY COLLISION". THESE EXTRA ELECTRONS ARE THEN ALSO ATTRACTED TO THE POSITIVELY CHARGED PLATE, IN ADDITION TO THOSE LIBERATED BY THE CATHODE AND THE RESULT IS THAT THE PHOTO-ELECTRIC CURRENT IS INCREASED OVER WHAT IT WOULD BE WITH THE FLOW OF PHOTO-ELECTRONS ALONE. (PHOTOELECTRONS ARE THE ELECTRONS WHICH ARE EMITTED FROM THE CATHODE OF THE PHOTO-CELL AND THE PHOTO-ELECTRIC CURRENT CORRESPONDS TO THE PLATE CURRENT OF AN ORDINARY RADIO TUBE.)

NOT ONLY IS THE PHOTO-ELECTRIC CURRENT AFFECTED BY THE INTENSITY OF THE LIGHT DIRECTED UPON ITS CATHODE SURFACE BUT A CHANGE IN THE POTENTIAL APPLIED TO THE ANODE WILL ALSO PRODUCE A PRONOUNCED EFFECT UPON THIS CURRENT.

THE WESTERN ELECTRIC SYSTEM

NOW LET US TURN OUR ATTENTION TO THE WESTERN ELECTRIC SYSTEM OF PRODUCING SOUND PICTURES. IN FIG.4, YOU ARE SHOWN A PIECE OF FILM AS USED IN THIS SYSTEM AND IN GENERAL APPEARANCE, THIS FILM IS SIMILAR TO ALL TYPES OF MOVING PICTURE FILM. THAT IS, THE FILM CONSISTS OF A LONG RIBBON, RESEMBLING THIN CELLULOID AND IT IS WOUND UP IN A ROLL. BY HOLDING A SECTION OF IT AGAINST A LIGHT, YOU CAN DISTINGUISH CHARACTERS, SCENERY, ETC. DUE TO THE DARK AND LIGHT SHADING, SIMILAR TO THAT WHEN YOU HOLD A NEGATIVE CAMERA FILM AGAINST A LIGHT.

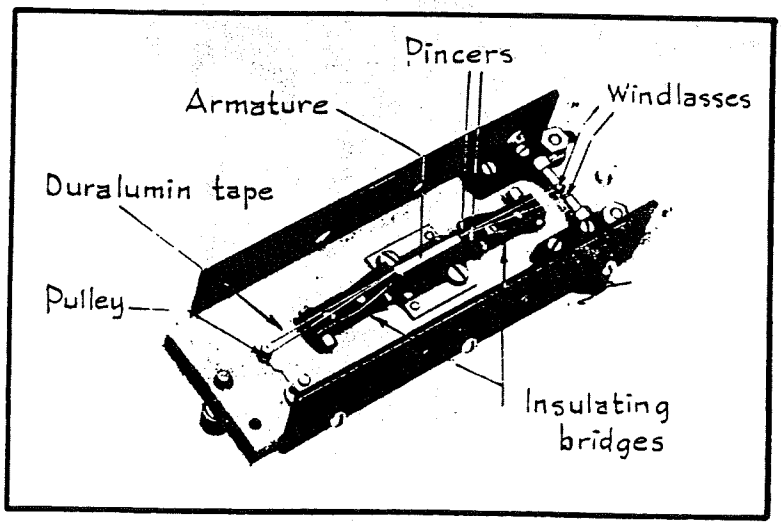

FIG.5

The Light Valve for Movietone Recording.

A CONTINUOUS ROW OF EQUALLY SPACED NOTCHES ARE LOCATED ALONG EACH EDGE OF THE FILM AS SHOWN IN FIG.4. WE HAVE LABELED THIS AS THE "DRIVE TRACK" BECAUSE SPROCKET COGS MESH WITH THESE HOLES, SO AS TO PULL THE FILM THROUGH THE PROJECTOR.

ANOTHER NARROW STRIP IS INCLUDED BETWEEN THE PICTURE STRIP AND THE LEFT DRIVE TRACK AND THIS IS THE SOUND TRACK. THE SOUND TRACK CONSISTS OF A LADDER-LIKE BAND OF SMALL LINES AND THIS IS THE FILM SOUND RECORD. AS YOU WILL NOTE, THESE TINY LINES IN THE SOUND TRACK ARE OF CONSTANT WIDTH BUT THE DENSITY VARIES. THAT IS, SOME PORTIONS ARE DARKER THAN OTHERS.

THE PITCH OF THESE FILM RECORDED SOUNDS IS REPRESENTED BY THE NUMBER OF CHANGES FROM DARK TO LIGHT AND BACK AGAIN IN A GIVEN LENGTH OFTHE

SOUND TRACK, WHILE THE DIFFERENCES IN THE INTENSITY OF SOUND ARE REPRESENTED BY THE DIFFERENCES IN THE DENSITY OF LIGHT AND SHADE ALONG THE SOUND TRACK. SINCE THE SOUND RECORD IN THIS CASE IS AN ACTUAL PART OF THE FILM, SYNCHRONIZATION BETWEEN SOUND AND SCENE PRESENTS NO PROBLEM IN THIS SYSTEM, BECAUSE THE RELATION BETWEEN THE SOUND TRACK AND THE FILM IS PERMANENTLY FIXED.

THE SECTION OF FILM IN FIG. 4 REPRESENTS A FINISHED FILM, READY TO BE RUN THROUGH A PROJECTOR BUT BEFORE WE CONSIDER THIS PART OF THE SUBJECT, YOU WILL OF COURSE FIRST WANT TO KNOW HOW THE SOUND ON FILM IS ORIGINALLY RECORDED.

THE MICROPHONE PICKUP, MONITORING, AND AMPLIFICATION OF THE AUDIO FREQUENCIES IS TAKEN CARE OF IN THE WESTERN ELECTRIC SYSTEM IN THE SAME WAY AS DESCRIBED RELATIVE TO THE VITAPHONE OR DISC RECORDING SYSTEM OF THE PREVIOUS LESSON. THE MAJOR DIFFERENCE BETWEEN THESE TWO SOUND RECORDING SYSTEMS IS FOUND AT THE RECORDING UNIT ITSELF.

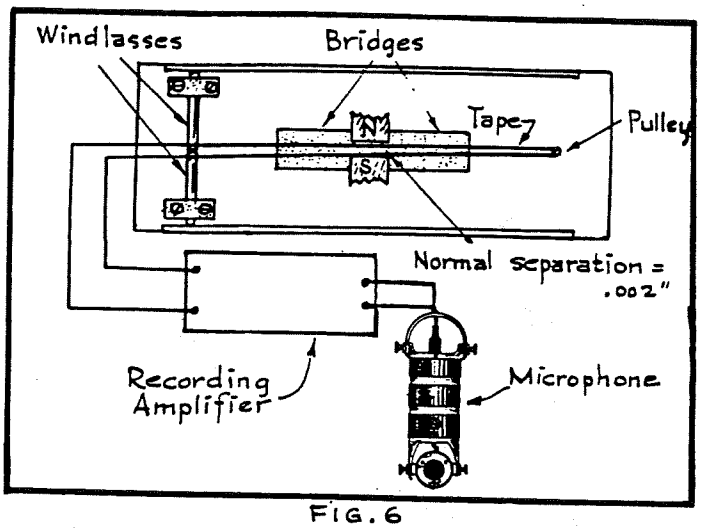

FIG. 6
Connection Between Light Valve and Ampl.

THE LIGHT VALVE

IN PLACE OF THE CUTTING DEVICE OF THE VITAPHONE SYSTEM, A LIGHT VALVE IS USED FOR THE SOUND RECORDING BY THE WESTERN ELECTRIC PROCESS. A PICTURE OF SUCH A LIGHT VALVE IS SHOWN IN FIG. 5. THIS DEVICE CONSISTS OF DURALUMIN TAPE 0.006" WIDE AND 0.003" THICK, WHICH IS SHAPED INTO AN OBLONG LOOP AND SUSPENDED IN A PLANE AT RIGHT ANGLES TO A MAGNETIC FIELD.

THE ENDS OF THE TAPE ARE SECURED AT THE WINDLASSES AS SHOWN IN FIG.5 AND IT IS STRETCHED TIGHT BY A SPRING-HELD PULLEY OVER WHICH THE LOOP IS PASSED. A PAIR OF INSULATED PINCERS CONFINE THE CENTRAL PORTIONS OF THE TAPE BETWEEN THE WINDLASSES AND PULLEY SO AS TO FORM A SLIT OR SPACE OF 0.002" BETWEEN THE TWO SIDES OF THE LOOP AT THIS POINT. SUPPORTING THIS LOOP AND THE ADJUSTING DEVICES IS A METAL SLAB WITH A CENTRAL ELEVATION, WHICH CONSTITUTES THE ARMATURE OF AN ELECTROMAGNET. THE CENTRAL PORTIONS OF THE DURALUMIN LOOP ARE SUPPORTED ON INSULATING BRIDGES JUST ABOVE THE FACE OF THE ARMATURE AND HERE THE SIDES OF THE LOOP ARE CENTERED OVER A TAPERED SLOT.

THE TWO SIDES AT THE CENTRAL PORTION OF THE LOOP CONSTITUTE A SLIT 0.002" WIDE BY 0.256" LONG, WITH ITS SIDES LYING IN A PLANE AT RIGHT ANGLES TO THE LINES OF FORCE AND APPROXIMATELY CENTERED IN THE AIR GAP. THE ENDS OF THE LOOP ARE CONNECTED TO THE OUTPUT TERMINALS OF THE RECORDING AMPLIFIER AS SHOWN IN FIG.6, WHERE THE LIGHT VALVE IS ILLUSTRATED TO EXAGGERATED PROPORTIONS FOR THE SAKE OF CLEARANCE. IF THE MAGNET IS ENERGIZED AND THE AMPLIFIER PASSES AN AUDIO FREQUENCY CURRENT THROUGH THE

LOOP, THEN THE LOOP WILL OPEN OR SPREAD APART AND AGAIN CLOSE IN ACCORDANCE WITH THE CURRENT VARIATION THROUGH IT. NOTICE IN FIG.6 THAT WE HAVE NOT INCLUDED THE MONITOR OR OTHER ACCESSORIES AND JUST THE BACK-BONE OF THE SYSTEM IS SHOWN FOR THE SAKE OF SIMPLICITY. IF A BEAM OF LIGHT IS DIRECTED AT THE CENTRAL PORTION OF THE LOOP, WHERE WE HAVE THE NORMAL SEPARATION OF .002", IT IS OBVIOUS THAT THE LIGHT BEAM PASSING THROUGH THIS RESTRICTION WILL BE MADE WIDER AND NARROWER ACCORDING TO THE OPENING AND CLOSING OF THE LOOP. FOR THIS REASON, IT IS CLEAR WHY THIS DEVICE IS CALLED A "LIGHT VALVE".

WHEN ONE SIDE OF THE AUDIO WAVE OPENS THE VALVE TO 0.004" AND THE OTHER SIDE CLOSES IT COMPLETELY, THEN FULL MODULATION OF THE APERTURE OR OPENING IS ACCOMPLISHED. THE NATURAL FREQUENCY OF THE VALVE IS SET BY ADJUSTING THE TENSION OF THE TAPE AND EXPERIENCE HAS SHOWN THAT BEST RESULTS ARE OBTAINED BY TUNING THIS LIGHT VALVE TO A FREQUENCY OF 7000 CYCLES PER SECOND. UNDER THESE CONDITIONS, ABOUT 10 MILLIWATTS OF POWER ARE REQUIRED FOR FULL MODULATION AT FREQUENCIES FAR AWAY FROM RESONANCE BUT ONLY ABOUT 1/100 OF THIS POWER IS REQUIRED AT THE RESONANT FREQUENCY.

SOUND RECORDING WITH THE WESTERN ELECTRIC SYSTEM

THE NEXT STEP IS TO SEE HOW THIS LIGHT VALVE IS USED IN THE RECORDING OF SOUND FILM. A SIMPLIFIED DIAGRAM OF THE WESTERN ELECTRIC SOUND RECORDING PROCESS IS SHOWN IN FIG. 7 AND FOR THE PRESENT, WE SHALL DEAL ONLY WITH THOSE ESSENTIAL PARTS HERE ILLUSTRATED.

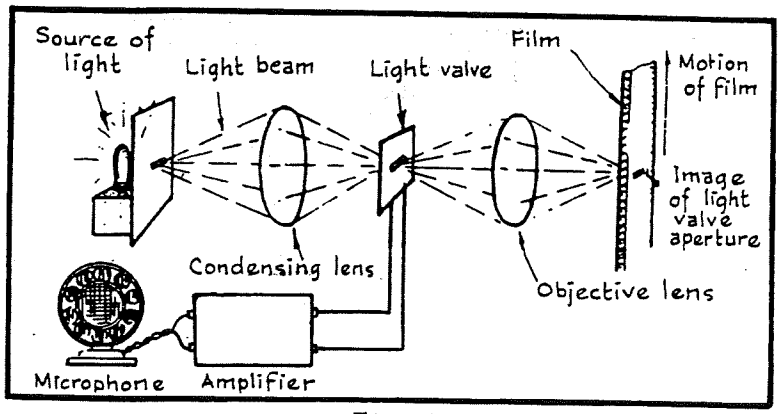

FIG.7
Movietone Process of Sound Recording.

AT THE LEFT OF FIG.7, WE HAVE OUR SOURCE OF LIGHT IN THE FORM OF A RIBBON-FILAMENT TYPE PROJECTION LAMP AND THIS IS FOCUSED UPON THE VARIABLE SLIT OF THE LIGHT VALVE BY MEANS OF A CONDENSING LENS SYSTEM.

ASSUMING FOR THE PRESENT THAT THE RECORDING AMPLIFIER IS NOT YET IN OPERATION, THE SLIT OF THE LIGHT VALVE WILL PASS A BEAM OF LIGHT, WHICH IS 0.002" WIDE AND 0.256" LONG AND THIS IS DIRECTED UPON AN OBJECTIVE LENS, WHICH IN TURN FOCUSES THIS BEAM WITH A TWO-TO-ONE REDUCTION UPON THE PHOTOGRAPHIC FILM AT THE FAR RIGHT. THE OPENING OF THE LIGHT VALVE NOW APPEARS ON THE FILM HALF-SIZE OR AS A LINE 0.001" WIDE AND 0.128" LONG, WITH ITS LENGTH BEING AT RIGHT ANGLES TO THE DIRECTION OF FILM TRAVEL.

NOW IF THE MICROPHONE CURRENTS ARE AMPLIFIED AND PERMITTED TO ACTUATE THE LOOP IN THE LIGHT VALVE, THE WIDTH OF THE LIGHT VALVE OPENING WILL VARY AT AUDIO FREQUENCIES AND THE SYSTEM IS THUS BEING MODULATED. THE LIGHT VALVE IS NOW OPERATING AS A CAMERA SHUTTER AND THE WIDTH OF

THE LIGHT LINE UPON THE FILM WILL VARY WITH THE SOUND CURRENTS, WHICH ARE SUPPLIED TO THE VALVE. IN THIS WAY, THE FILM RECEIVES EXPOSURE TO LIGHT OF FIXED INTENSITY BUT DURING THE VARYING TIME REQUIRED FOR A GIVEN POINT ON THE FILM TO PASS THE VARYING OPENING OF THE LIGHT VALVE SLIT.

THIS BEING THE CASE, WE FIND THAT AS THE FILM MOVES PAST THE FOCUSING POINT OF THE OBJECTIVE LENS, THE CONDENSATIONS AND RAREFACTIONS OF THE ORIGINAL SOUND WAVES WILL BE RECORDED AS LIGHT AND DARK VARIATIONS, DUE TO THE CORRESPONDING VARIATION IN EXPOSURE OF THE FILM TO LIGHT AS CAUSED BY THE VALVE.

DURING THE FILMING OF A PICTURE, THE SOUND IS RECORDED ON A FILM SEPARATE FROM THAT WHICH RECEIVES THE PICTURE. THIS PERMITS THE USE OF TWO MACHINES, SO THAT DUPLICATE SOUND RECORDS CAN BE MADE AND CONSEQUENTLY, IF ONE SHOULD BE DEFECTIVE FOR SOME REASON OR OTHER, THE SECOND WILL COME IN MIGHTY HANDY. ANOTHER IMPORTANT REASON FOR HAVING SEPARATE NEGATIVES FOR SOUND AND PICTURE IS THAT THIS PRACTICE PERMITS A SEPARATE AND SPECIAL DEVELOPING PROCEDURE FOR EACH. THIS IS ESPECIALLY DESIRABLE WITH RESPECT TO THE SOUND FILM BECAUSE IT IS NECESSARY THAT THIS FILM BE DEVELOPED TO UNIFORM INTENSITY THROUGHOUT ITS ENTIRE LENGTH, IN ORDER TO PROVIDE PROPER SOUND PROJECTION.

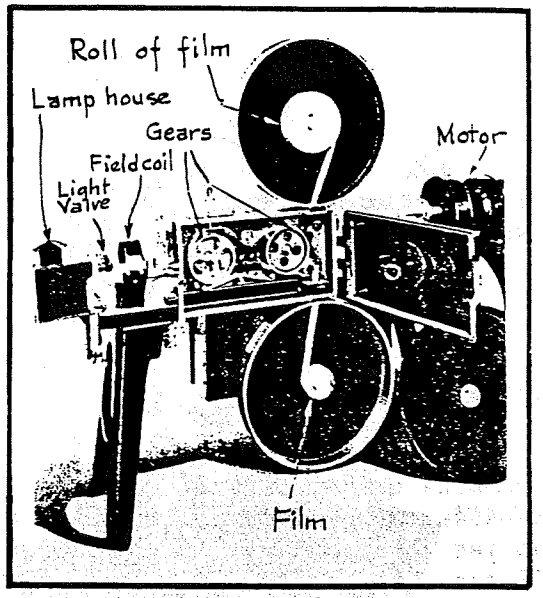

FIG. 8
Movietone Sound Recorder.

THE SOUND RECORDING MACHINE IS DRIVEN IN PERFECT SYNCHRONISM WITH THE CAMERA AND TO INSURE AGAINST ANY VARIATION IN THE VELOCITY OF THE SOUND FILM PAST THE LINE OF LIGHT EXPOSURE, THE SPROCKET WHICH CARRIES THE FILM AT THAT POINT IS DRIVEN THRU A MECHANICAL FILTER, WHICH HOLDS THE INSTANTANEOUS VELOCITY CONSTANT TO ONE PART IN ONE THOUSAND.

IN FIG. 8, YOU WILL SEE SUCH A RECORDING MACHINE, WITH THE DOOR OF THE EXPOSURE CHAMBER OPENED SO THAT THE INNER CONSTRUCTION CAN BE OBSERVED. IN ORDER THAT THE OPERATORS OF THE RECORDING EQUIPMENT MAY KNOW THE QUALITY OF THE RECORDING DURING THE TIME IT IS BEING MADE, A SOUND PICK-UP DEVICE IS INCORPORATED WITHIN THE RECORDING MACHINE. IN THIS WAY, THE SOUNDS CAN BE REPRODUCED DIRECTLY AS THEY ARE BEING RECORDED.

THE PICK-UP DEVICE FOR SOUND REPRODUCTION

THIS PICK-UP DEVICE CONSISTS OF A PHOTO-CELL, WHICH IS MOUNTED WITHIN THE EXPOSURE CHAMBER OF THE RECORDING MACHINE BEHIND THE LEFT HAND SPROCKET AS VIEWED IN FIG.8. FRESH FILM TRANSMITS ABOUT 4% OF THE LIGHT WHICH STRIKES IT AND SO THE BEAM OF LIGHT PENETRATES THE FILM AS SHOWN IN FIG.9 AND ENTERS THE WINDOW OF THIS PHOTO-CELL.

THE AMOUNT OF LIGHT, WHICH ACTS UPON THE LIGHT-SENSITIVE MATERIAL

OF THE PHOTO CELL, WILL BE DETERMINED BY THE DENSITY OF THE PORTION OF THE SOUND TRACK, WHICH HAPPENS TO OBSTRUCT THE PATH OF THIS LIGHT BEAM AT ANY ONE INSTANT. THEREFORE, THE INTENSITY OF THE LIGHT ACTING UPON THE PHOTO-CELL WILL VARY IN DIRECT PROPORTION TO THE LIGHT AND DARK PORTIONS ON THE FILM SOUND TRACK AND SINCE THESE ARE DISTRIBUTED ACCORDING TO AUDIO FREQUENCIES, THE LIGHT BEAM ACTING UPON THE PHOTO-CELL WILL VARY AT A CORRESPONDING FREQUENCY.

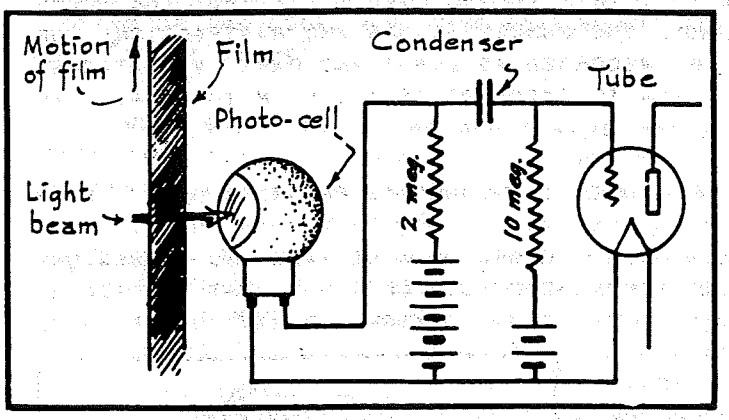

FIG. 9
Monitoring Photo-cell Pick-up.

THE ELECTRON EMISSION FROM THE PHOTO-CELL'S CATHODE WILL INCREASE AND DECREASE IN PROPORTION TO THESE VARIATIONS IN LIGHT INTENSITY, WITH THE RESULT THAT THE PHOTO-CELL CURRENT DOES LIKEWISE. THUS BY HAVING A VARIATION OF PHOTO-CELL CURRENT FLOWING THROUGH THE 2 MEGHOM RESISTOR OF FIG. 9, SIGNAL VOLTAGES OF CORRESPONDING FREQUENCY ARE DEVELOPED ACROSS THIS RESISTOR AND THESE SIGNAL POTENTIALS ACT THROUGH THE FIXED CONDENSER AND IMPRESS THEMSELVES ACROSS THE GRID CIRCUIT OF THE AMPLIFYING TUBE.

THESE AUDIO SIGNALS, WHEN APPLIED TO THE GRID CIRCUIT OF THE AMPLIFYING TUBE, UNDERGO CONVENTIONAL A.F. AMPLIFICATION AND BY ADDING ADDITIONAL AMPLIFYING STAGES, THE SIGNAL ENERGY CAN BE RAISED TO A SUFFICIENTLY HIGH LEVEL SO AS TO OPERATE A SPEAKER IN THE CONVENTIONAL MANNER.

THE SPEAKER IN THIS CASE IS IN THE MONITORING ROOM, THE PRELIMINARY AMPLIFIER OF FIG. 9 IS LOCATED BELOW THE EXPOSURE CHAMBER OF THE RECORDING MACHINE, AND THE ADDITIONAL AMPLIFIER IS ONE SEPARATE FROM THAT DOING THE REGULAR RECORDING AMPLIFICATION.

RECORDING PRACTICE

IN STUDIO PRODUCTION, THE MIXER OPERATOR IS STATIONED IN THE MONITORING ROOM AND HE VIEWS THE "SET" (STAGE SET-UP) THRU A DOUBLE WINDOW IN THE STUDIO WALL AND IN ADDITION TO OPERATING THE MIXER PANEL FOR COMBINING THE CONTRIBUTIONS OF SEVERAL MICROPHONES, HE ALSO CONTROLS THE GAIN OF THE AMPLIFIERS FOR THE RECORDING MACHINES.

BY MEANS OF RELAY SWITCHES, THE MIXER OPERATOR CAN CONNECT THE MONITORING HORN CIRCUIT EITHER DIRECTLY TO THE RECORDING AMPLIFIER, AS WAS SHOWN YOU RELATIVE TO V1

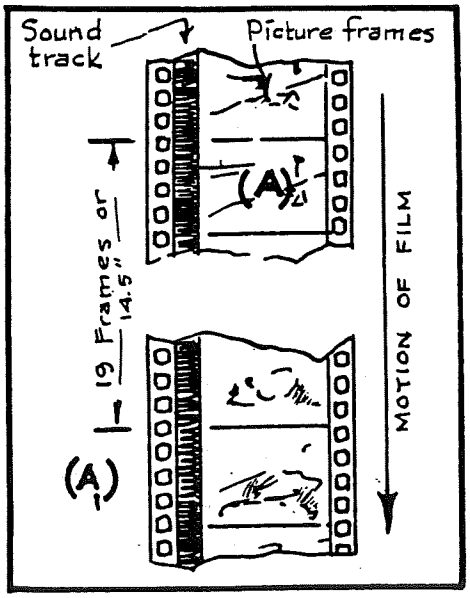

FIG. 10
Picture-Sound Track Relation.

TAPHONE OR DISC RECORDING IN THE PREVIOUS LESSON, OR ELSE HE CAN CONNECT THE HORN CIRCUIT TO ONE OR THE OTHER OF THE PHOTO-CELL PICK UP CIRCUITS, WHICH WAS DESCRIBED A FEW MOMENTS AGO.

DURING THE TIME THAT PRELIMINARY TESTS ARE BEING CARRIED OUT SO AS TO DETERMINE THE BEST MICROPHONE POSITION ON THE SET ETC., THE MONITORING HORN CIRCUIT IS CONNECTED DIRECTLY TO THE OUTPUT END OF THE RECORDING AMPLIFIER. THE PROGRAM IS THEN REHEARSED ON THE SET UNTIL A SATISFACTORY ARRANGEMENT OF THE MICROPHONES AND OF AMPLIFIER GAIN IS DETERMINED.

THE ELECTRICAL CHARACTERISTIC OF THIS MONITORING CIRCUIT IS SO DESIGNED THAT THE SOUND QUALITY HEARD IN THE MONITORING HORNS SHALL BE THE SAME AS THE QUALITY TO BE EXPECTED IN THE REPRODUCTION OF THE POSITIVE PRINT IN THE THEATER. THE WALLS OF THE MONITORING ROOM ARE ACOUSTICALLY TREATED IN SUCH A WAY THAT ITS REVERBERATION CHARACTERISTICS WILL BE THE SAME AS THAT IN THE THEATER AND THE MONITORING LEVEL IS SO ADJUSTED THAT THE MIXER OPERATOR HEARS THE SAME LOUDNESS THAT HE WOULD WISH TO HEAR FROM THE THEATER HORNS. IT IS VERY IMPORTANT THAT THE OPERATOR JUDGE HIS PICK-UP ON THE BASIS OF SOUND CLOSELY IDENTICAL IN LOUDNESS AND QUALITY WITH THAT TO BE HEARD LATER IN THEATER REPRODUCTION.

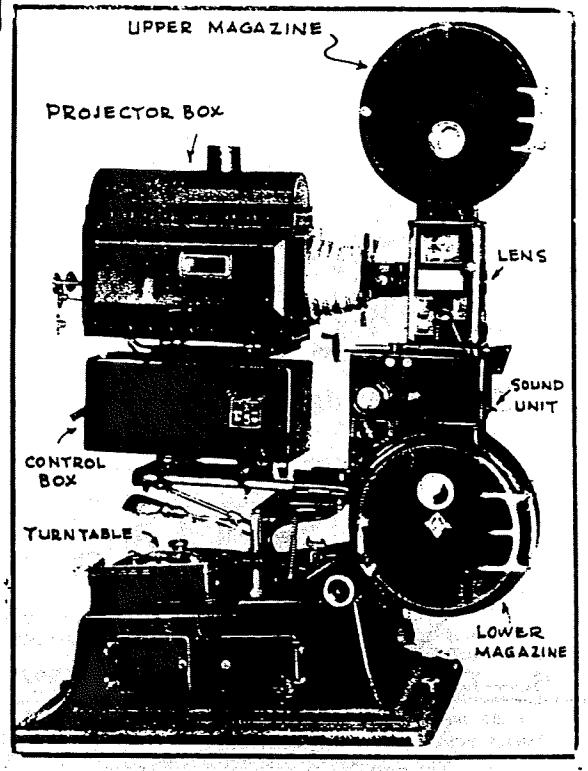

FIG.11
A Motion Picture Projector for Disc and Film Recording.

WITH EVERYTHING ADJUSTED TO THE POINT DESIRED, THE OUTPUT OF THE RECORDING AMPLIFIER IS DISCONNECTED FROM THE MONITORING HORNS AND IS NOW CONNECTED TO THE LIGHT VALVES OF THE RECORDING MACHINES AND THE MONITORING HORNS ARE CONNECTED TO THE PHOTO-CELL AMPLIFIERS OF THE RECORDING MACHINES. WITH NO FILM IN THE MACHINE AND AT A CONVENIENT LAMP CURRENT, A COMPLETE REHEARSAL IS MADE SO AS TO VERIFY THE OPERATION OF THE LIGHT VALVES AT THE PROPER LEVEL. FILM IS THEN LOADED, THE CAMERAS AND SOUND RECORDERS ARE INTERLOCKED AND STARTING MARKS ARE MADE ON ALL FILMS EITHER BY MEANS OF PUNCHES OR ELSE WITH FLASHES OF LIGHT UPON THE STARTING POINT OF THE FILM.

THE STUDIO AND RECORDING ROOM SIGNAL TO EACHOTHER BY MEANS OF LIGHTS AND SO WHEN THE RECORDING EQUIPMENT IS READY FOR ACTION, THE RECORDING ROOM WARNS THE STUDIO BY MEANS OF A LIGHT SIGNAL. THE LIGHTING EFFECTS ON THE STAGE ARE THEN PUT INTO OPERATION AND THE STUDIO THEN SIGNALS BACK ITS READINESS TO START.

THE MACHINE OPERATORS START THE CAMERAS AND SOUND RECORDERS, BRING-

ING UP THE LAMP CURRENT TO THE PROPER VALUE AND WHEN THE MACHINES ARE UP TO SPEED, A SIGNAL IS GIVEN THE STUDIO, NOTIFYING THEM TO START. DURING THE RECORDING PROCESS, THE MIXER OPERATOR MONITORS THE RECORDING THROUGH THE LIGHT VALVES, THUS ASSURING HIMSELF THAT NONE OF THE RECORDING IS BEING LOST.

COMBINING THE SOUND AND PICTURE FILM

WE WILL NOW HAVE THE PICTURES ON A FILM SEPARATE FROM THAT ON WHICH THE SOUNDS ARE RECORDED AND SO THE NEXT STEP IS TO COMBINE THESE TWO INTO A SINGLE FILM, WITH THE SOUND TRACK RUNNING ALONG THE EDGE OF THE PICTURE PORTION OF THE FILM AS SHOWN IN FIG. 4. IN PRINTING THE SOUND NEGATIVES IN COMBINATION WITH PICTURES FOR PROJECTION IN THE THEATER, IT IS CUSTOMARY TO FIRST PRINT THE PICTURE NEGATIVE, MASKING (COVERING) THE SPACE NEEDED FOR THE SOUND TRACK AND TO RUN THE RESULTING PICTURE POSITIVE THRU THE PRINTER AGAIN, TOGETHER WITH THE SOUND NEGATIVE, THIS TIME MASKING THE SPACE ALREADY PRINTED. IN PRINTING THE SOUND NEGATIVE, THE LIGHT IS REGULATED TO RESULT IN 35% TRANSMISSION OF THE UNMODULATED TRACK AFTER POSITIVE DEVELOPMENT.

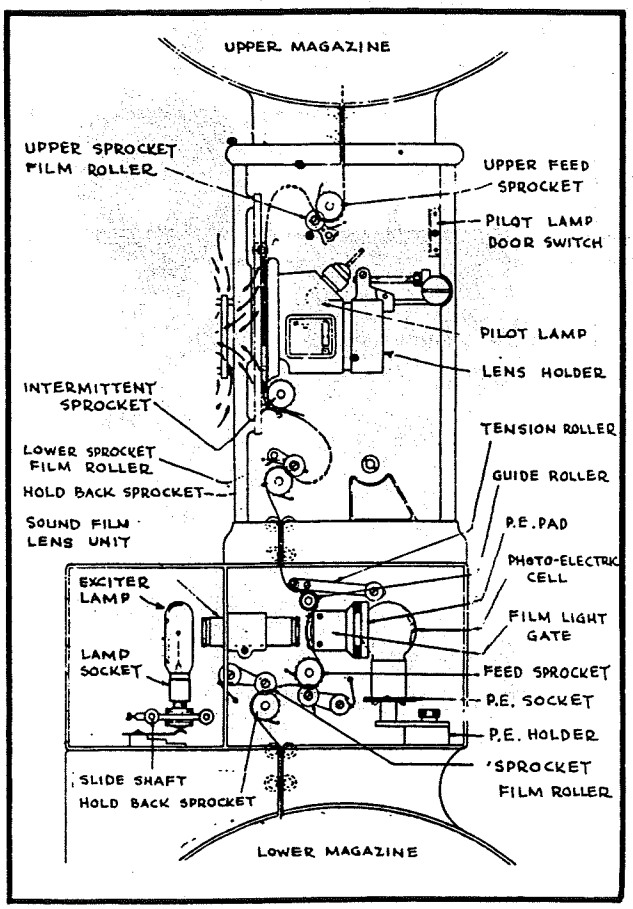

FIG. 12

Inner Construction of the Projector.

UPON COMBINING THE SOUND TRACK WITH PICTURES UPON A SINGLE FILM, THE SOUND RECORDING AT THE SIDE OF ANY ONE PARTICULAR PICTURE FRAME DOES NOT CORRESPOND TO THE ACCOMPANYING PICTURE. TO ILLUSTRATE THIS, STUDY FIG. 10 CAREFULLY AND YOU WILL NOTE THAT WE HAVE LABELED ONE OF THE PICTURE FRAMES (A). THE SOUND RECORDING TO CORRESPOND WITH FRAME (A) IS AT THE POINT WHICH IS LABELED (A). BETWEEN THEM THERE IS A SEPARATION OF 19 PICTURE FRAMES OR 14.5".

THE REASON FOR USING SUCH AN ARRANGEMENT IS THAT IN THE THEATER PROJECTOR, THE SOUND GATE IS LOCATED 14.5" BELOW THE PICTURE GATE, IN ORDER TO PROJECT THE SOUND RECORDING AT A POINT WHERE THE FILM IS IN CONTINUOUS MOTION. THIS WILL BE SHOWN MORE CLEARLY DURING OUR DISCUSSION OF PROJECTION WITH THE MOVIETONE SYSTEM.

THE MOTION PICTURE PROJECTOR FOR SOUND ON FILM

IN FIG. 11, YOU WILL SEE A MOTION PICTURE PROJECTOR, WHICH IS EQUIP-

PED FOR BOTH SOUND ON DISC REPRODUCTION, AS WELL AS FOR THE REPRODUCTION OF SOUND ON FILM. THE INNER CONSTRUCTION OF THIS SAME PROJECTOR IS SHOWN IN FIG.12.

BY REFERRING TO FIG.12, YOU WILL SEE THAT THE FILM IS THREADED FROM THE UPPER MAGAZINE PAST THE PICTURE PROJECTOR LENS AND THENCE PAST THE SOUND FILM LENS UNIT AND INTO THE LOWER MAGAZINE. VARIOUS SPROCKETS AND ROLLERS ARE USED IN SUCH AN ARRANGEMENT SO THAT THE FILM IS FED THRU THE MACHINE AT A UNIFORM RATE AND UNDER PROPER TENSION.

NOTICE THAT THE PICTURE LENS IS ABOVE THE SOUND FILM LENS, SO THAT ANY POINT OF THE FILM MUST PASS THE PICTURE PROJECTING LENS BEFORE ARRIVING AT THE SOUND FILM LENS UNIT. OBVIOUSLY, THE SOUND RECORDING MUST BE ADVANCED AHEAD OF THE CORRESPONDING PICTURE FRAMES, AS ALREADY DESCRIBED, SO THAT SOUND REPRODUCTION WILL OCCUR SYNCHRONOUSLY WITH THE CORRESPONDING PICTURE.

A POWERFUL LIGHT AND LENS SYSTEM PROJECTS THE PICTURE UPON THE SCREEN OF THE THEATER, AS THE SOUND EQUIPMENT REPRODUCES THE SOUNDS IN SPEAKERS LOCATED BEHIND THE SCREEN.

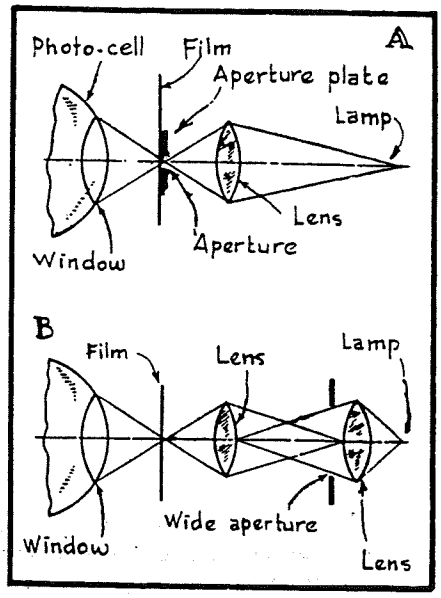

FIG.13
Lens Systems Used in Movietone Producers.

SOUND REPRODUCTION

CONSIDERING THE SOUND PICK-UP DEVICE OF FIG.12 IN GREATER DETAIL, WE SEE FIRST THE "EXCITER LAMP". THIS IS A SMALL INCANDESCENT LAMP, WHICH HAS A RELATIVELY HIGH CURRENT AND LOW VOLTAGE CAPACITY, CONSUMING BETWEEN 32 AND 75 WATTS. THE CURRENT FOR LIGHTING THIS FILAMENT MUST BE A PURE DIRECT CURRENT BECAUSE ANY VARIATION IN THE CURRENT WILL CAUSE A CORRESPONDING CHANGE IN THE PHOTO-ELECTRIC CELL CURRENT. THAT IS, IF A 60 CYCLE A.C. SUPPLY WERE USED FOR THIS LAMP, ITS FILAMENT WOULD COOL AND HEAT UP ALTERNATELY AT THE RATE OF 120 TIMES PER SECOND AND ALTHOUGH THESE CORRESPONDING VARIATIONS IN LIGHT INTENSITY WILL BE UNOTICEABLE TO THE HUMAN EYE, YET THEY ARE READILY DETECTED BY THE PHOTO-CELL, WITH THE RESULT THAT A 120 CYCLE ROAR WOULD BE EMITTED BY THE SPEAKERS. IN FACT, EVEN THE ARMATURE RIPPLES OF A D.C. GENERATOR ARE REPRODUCED BY THE PHOTO-CELL, IF USED AS THE FILAMENT SUPPLY FOR THE EXCITER LAMP. BATTERIES ARE THE SOLUTION TO THIS PROBLEM.

THE NEXT THING IS TO FOCUS THIS LIGHT OF THE EXCITER LAMP UPON THE SOUND TRACK OF THE FILM AND THIS IS ACCOMPLISHED BY THE SOUND FILM LENS UNIT OF FIG.12.

THE DETAILS OF SUCH A LIGHT FOCUSING ARRANGEMENT ARE SHOWN IN FIG. 13. OUR OBJECT NOW IS TO IMPRESS A SMALL SHARP RECTANGULAR SHAPED BEAM OF LIGHT UPON THE SOUND TRACK OF THE FILM. THE EASIEST WAY TO DO THIS IS ILLUSTRATED AT "A" OF FIG.13, WHERE WE HAVE AN "APERTURE PLATE" PLACED

CLOSE UP AGAINST THE FILM AND A SLIT 0.001" IN WIDTH IS CUT IN THIS PLATE, AND THUS FORMS THE "APERTURE".

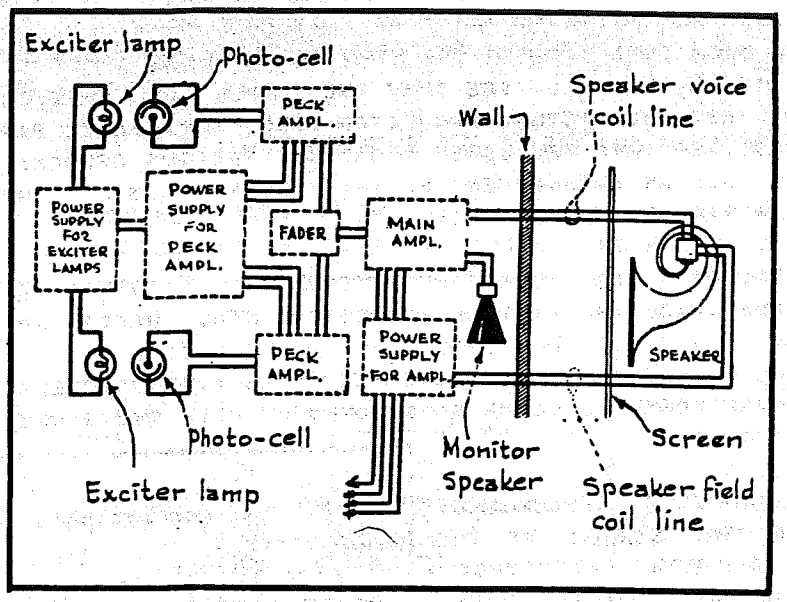

FIG. 14

Sound Reproducing System for Film Recording

BY MEANS OF A SUITABLE LENS, THE LIGHT FROM THE EXCITER LAMP CAN BE FOCUSED UPON THIS SLIT AND THUS PENETRATE THE FILM SOUND TRACK IN THE SHAPE OF A SMALL NARROW RECTANGLE. THIS METHOD, HOWEVER, IS NOT PRACTICAL BECAUSE A SLIT AS THIS, WITH AN AREA OF ONLY ABOUT 0.0001 SQ. IN., CANNOT BE KEPT FREE FROM FOREIGN MATTER FOR ANY LENGTH OF TIME WHEN PLACED CLOSE AGAINST A RAPIDLY MOVING FILM.

FOR THE REASON MENTIONED, THE SYSTEM WAS IMPROVED TO THAT SHOWN AT "B" OF FIG. 13. IN THIS CASE, THE APERTURE SLIT IS MOVED AWAY FROM ITS EXPOSED POSITION NEAR THE FILM, IT IS SEALED WITHIN A LENS SYSTEM, MADE CONSIDERABLY WIDER AND LONGER AND THEN OPTICALLY REDUCED TO A LIGHT RECTANGLE OF 0.001"X 0.1" ON THE FILM BY MEANS OF THE SYSTEM OF LENSES. THUS THE RESULT IS THE SAME AS OBTAINED AS WITH THE CLOSE-UP SLITSYSTEM BUT WITHOUT ITS DISADVANTAGES.

THIS NARROW BAND OF LIGHT, WHICH IS THUS FOCUSED UPON THE FILM SOUND TRACK, WILL PENETRATE THE FILM AND THEN BE DIRECTED AGAINST THE LIGHT-SENSITIVE ELEMENT OF A PHOTO-ELECTRIC CELL AND THE INTENSITY OF THIS LIGHT, WHICH IS PASSED BY THE FILM WILL OF COURSE BE GOVERNED BY THE DENSITY OF THE SOUND TRACK, WHICH IS EXPOSED TO THE LIGHT.

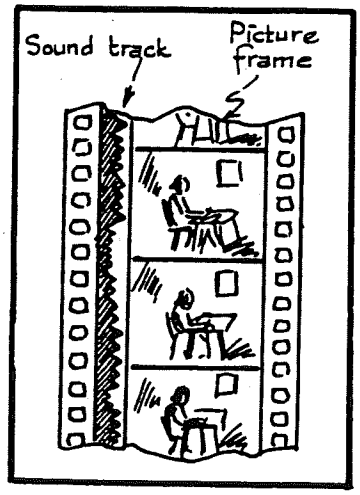

FIG. 15

The Photophone Film.

THIS PHOTO-CELL IS COUPLED TO A PICK-UP AMPLIFIER, AS ALREADY SHOWN YOU IN FIG. 9 OF THIS LESSON, AND THUS THE PHOTO-CELL CURRENT WILL VARY ACCORDING TO THE LIGHT AND DARK PORTIONS ON THE FILM SOUND TRACK. IN THIS WAY, LIGHT VARIATIONS OF AUDIO FREQUENCY ARE CHANGED INTO ELECTRICAL CURRENT VARIATIONS OF CORRESPONDING FREQUENCY.

THE PHOTO-CELL PICK-UP AMPLIFIER IS GENERALLY REFERRED TO AS A "PECK AMPLIFIER". THIS AMPLIFIER USUALLY CONSISTS OF TWO OR THREE STAGES OF CASCADE AMPLIFICATION, USING VARIOUS TYPES OF COUPLING, BUT RESISTANCE-CAPACITY COUPLING PRODUCES

THE BEST RESULTS. THE CURRENT USED FOR OPERATING THE PECK AMPLIFIER MUST BE PURE D.C , SUPPLIED EITHER BY STORAGE BATTERIES OR DRY CELLS. DUE TO THE FEEBLE CURRENT FROM THE PHOTO-CELL, THE PECK AMPLIFIER HAS TO MAGNIFY IT FROM ABOUT 100 TO 200 TIMES AND THEREFORE ANY VARIATION IN THE POWER SUPPLY FOR THIS AMPLIFIER, NO MATTER HOW LITTLE, WILL BE REPRODUCED AT GREAT VOLUME BY THE SPEAKERS.

IN FIG. 14, YOU WILL SEE THE LAYOUT FOR THE REPRODUCTION OF SOUND FROM FILM. TWO PROJECTORS ARE REQUIRED IN THE PROJECTION BOOTH, THE SAME AS FOR DISC RECORDINGS OR EVEN FOR SILENT PICTURES FOR THAT MATTER. NOTICE HOW THE EXCITER LAMP FOR EACH PROJECTOR IS SUPPLIED WITH BATTERY FILAMENT CURRENT AND HOW EACH OF THE PHOTO-CELLS FEEDS INTO A PECK AMPLIFIER. BOTH OF THESE PICK-UP AMPLIFIERS FEED INTO A FADER, THROUGH WHICH THEIR ENERGY PASSES INTO THE MAIN AMPLIFIER. THE MAIN AMPLIFIER THEN PASSES THE AMPLIFIED AUDIO CURRENTS THROUGH THE HUGE SPEAKERS, WHICH ARE LOCATED BEHIND THE SCREEN UPON WHICH THE PICTURE IS BEING PROJECTED. THE SOUND THUS APPEARS TO THE AUDIENCE AS COMING FROM THE REPRODUCTIONS ON THE SCREEN. A MONITOR HORN IS LOCATED IN THE BOOTH FOR THE OPERATOR'S USE.

THE FILM IS RUN THROUGH THE PROJECTION MACHINE AT THE RATE OF 90 FT. PER MINUTE AND IT IS ESSENTIAL THAT THIS SPEED BE KEPT CONSTANT, AS OTHERWISE THE PITCH OF THE SOUND WILL CHANGE IN THE SAME MANNER AS WHEN THE SPEED OF A PHONOGRAPH TURNTABLE VARIES. AS A RULE, A LARGE FLYWHEEL IS DIRECTLY COUPLED TO THE FILM FEED SPROCKET FOR THE PURPOSE OF INSURING A STEADY ROTATION OF THIS SPROCKET, SO THAT THE FILM WILL BE CARRIED PAST THE BEAM OF LIGHT FROM THE EXCITER LAMP AT A CONSTANT SPEED.

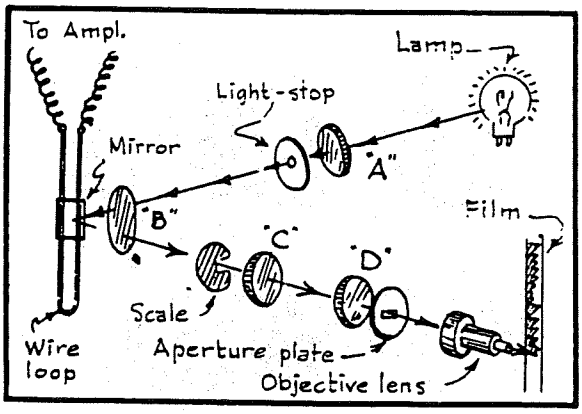

FIG. 16
Photophone Recording Device.

THE PHOTOPHONE SYSTEM

NOW LET US TURN OUR ATTENTION TO THE PHOTOPHONE SYSTEM OF SOUND RECORDING ON FILM. A SECTION OF FILM, AS USED BY THIS SYSTEM, IS SHOWN IN FIG.15 AND AS A WHOLE, IT IS QUITE SIMILAR TO THE MOVIETONE FILM IN THAT IT HAS A SOUND TRACK IN CONJUNCTION WITH THE PICTURE STRIP. THE PHOTOPHONE SOUND TRACK, HOWEVER, IS OF THE CONSTANT DENSITY, VARIABLE WIDTH TYPE AND THE DEGREE OF SHADING IS THE SAME BUT A VARIABLE PORTION OF THE SOUND TRACK IS DARKENED.

IN PRODUCING A PICTURE WITH THE PHOTOPHONE SYSTEM, THE MICROPHONE PICK-UP, MONITORING, AMPLIFYING ETC. IS ALL CARRIED OUT IN THE SAME MANNER AS WITH EITHER DISC RECORDING OR MOVIETONE RECORDING. ALL OF THESE SYSTEMS DIFFER FROM EACHOTHER MAINLY AT THE RECORDING DEVICE ITSELF AND THE RECORDING UNIT, AS USED WITH PHOTOPHONE, IS DIFFERENT FROM ANY SO FAR SHOWN YOU. THE PHOTOPHONE RECORDER IS CLASSIFIED AS A VARIABLE AREA RECORDER AND IT IS DIAGRAMATICALLY ILLUSTRATED IN FIG.16.

THE RECORDING UNIT FOR THE PHOTOPHONE SYSTEM

WE COMMENCE IN FIG.16 WITH OUR SOURCE OF LIGHT, WHICH IN THIS CASE IS A LAMP OPERATED AT HIGH BRILLIANCY FROM A 6 TO 8 VOLT STORAGE BATTERY. A SPHERICAL LENS "A" FOCUSES THIS BEAM OF LIGHT THROUGH A HOLE IN THE "LIGHT-STOP" WHICH SERVES AS A FRAMING DEVICE. THE BEAM OF LIGHT, WHICH PASSES THROUGH THE OPENING OF THE LIGHT-STOP IS DIRECTED TOWARDS ANOTHER SPHERICAL LENS "B" AND THIS LENS IN TURN FOCUSES IT UPON A SMALL MIRROR, WHOSE DIMENSIONS ARE ABOUT 1/20 OF AN INCH ON A SIDE.

THIS MIRROR REFLECTS THE LIGHT BACK THROUGH LENS "B" AT AN ANGLE, AS SHOWN BY THE ARROWS, AND THE BEAM IS THEN DIRECTED THROUGH THE GROOVE OF A SCALE UPON WHICH THE AMPLITUDE OF RECORDING CAN LATER BE MEASURED. THE LIGHT BEAM CONTINUES THROUGH A CYLINDRICAL LENS "C", A SPHERICAL LENS "D", AND THENCE THROUGH A NARROW SLOT IN THE APERTURE PLATE.

THE OBJECTIVE LENS GENERALLY HAS A REDUCTION RATIO OF 4 TO 1, SO THAT IF THE SLIT IN THE APERTURE PLATE IS 0.320" BY 0.004", THE IMAGE PRODUCED ON THE FILM WILL BE 0.080" BY 0.001". THAT IS, THIS SMALL RECTANGLE OF LIGHT UPON THE FILM WILL BE 0.080" LONG (HORIZONTALLY WITH RESPECT TO THE FILM) AND 0.001" WIDE, AND THIS WILL PRODUCE A SOUND TRACK 0.080" WIDE, WHICH IS CLOSE TO THE STANDARD WIDTH USED IN PRACTICE.

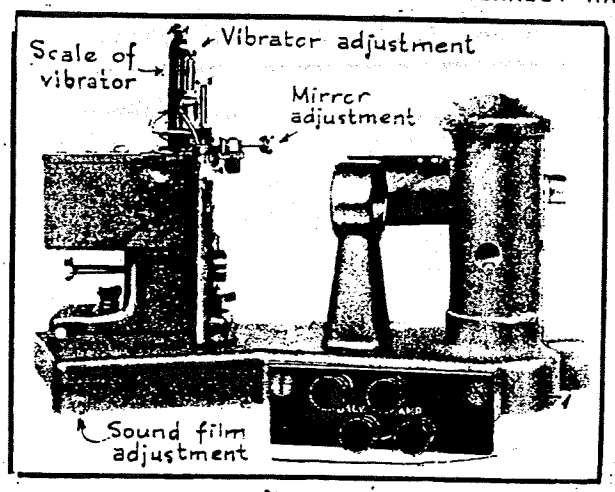

FIG 17
Housing and Adjustments of the Recorder

AUDIO MODULATION WITH LIGHT

THE TINY MIRROR IS CEMENTED TO TWO SIDES OF A WIRE LOOP AND THIS WIRE LOOP IS STRETCHED TAUT AT RIGHT ANGLES TO A MAGNETIC FIELD. THE ENDS OF THIS LOOP ARE CONNECTED TO THE OUTPUT TERMINALS OF THE RECORDING AMPLIFIER AND THEREFORE WHEN THE AUDIO FREQUENCY CURRENTS FLOW THROUGH THE LOOP, THE RESULTING VARIATIONS IN ITS MAGNETIC FIELD WILL REACT WITH THE PERMANENT MAGNETIC FIELD SO AS TO PRODUCE MOTION. THE MOVING PART IN THIS CASE IS THE WIRE LOOP WITH ITS ATTACHED MIRROR AND WITH THE LOOP TURNING BACK AND FORTH OR VIBRATING ABOUT A VERTICAL AXIS IN DIRECT STEP WITH THE AUDIO FREQUENCY CURRENT VARIATIONS THROUGH IT.

THE WIRE LOOP IS STRETCHED TO THE POINT WHERE THE RESONANT VIBRATING FREQUENCY IS ABOUT 7000 CYCLES. THIS ENTIRE VIBRATING SYSTEM, CONSISTING OF THE LOOP WITH ITS MIRROR, IS MOUNTED IN A CASE CONTAINING A DAMPING FLUID, WHICH IS GENERALLY A MIXTURE OF CASTOR OIL AND TURPENTINE. THE LENS "B" SERVES AS THE WINDOW OF THE FLUID-FILLED CELL IN WHICH THE MIRROR IS MOUNTED AND THE FLUID IS CHANGED EVERY FEW MONTHS, SO THAT IT IS ALWAYS TRANSPARENT TO THE LIGHT IN THE THIN LAYER INTERPOSED BETWEEN THE MIRROR AND LENS "B". IN REALLITY, THIS DEVICE IS NOTHING MORE THAN AN OSCILLOGRAPH, WHICH IS A LABORATORY INSTRUMENT USED

FOR THE RECORDING OF ALTERNATING CURRENTS.

THE ARRANGEMENT IS SLIGHTLY TILTED IN PRACTICE, SO THAT THE LIGHT REFLECTED BY THE MIRROR WILL CONTINUE ALONG THE AXIS TOWARD THE FILM AS SHOWN IN FIG.16.

RECORDING WITH PHOTOPHONE SYSTEM

THE WHOLE SYSTEM IS LINED UP, SO THAT ONE EDGE OF THE HOLE IN THE LIGHT STOP IS IMAGED IN THE MIDDLE OF THE SOUND TRACK ON THE FILM WHEN THERE IS NO INPUT TO THE MICROPHONES AND WHEN THE MIRROR IS IN ITS NEUTRAL POSITION. IF THE FILM IS MOVED PAST THIS RECTANGULAR BEAM OF LIGHT AT A CONSTANT SPEED OF 90 FT. PER MINUTE WITH NO SOUND IMPINGED UPON THE RECORDING MICROPHONE, THEN THE RESULTING RECORD AFTER DEVELOPEMENT WOULD APPEAR AS A DARK BAND ON THE SOUND NEGATIVE, COVERING HALF THE WIDTH OF THE SOUND TRACK.

NOW WHEN THE MICROPHONE, AMPLIFIER ETC. ARE IN OPERATION, THE AUDIO FREQUENCY CURRENTS WILLFLOW THROUGH THE WIRE LOOP, THEREBY CAUSING THE LOOP AND ITS ATTACHED MIRROR TO OSCILLATE ON ITS PIVOT. THIS MOVEMENT OF THE MIRROR IS IN DIRECT STEP WITH THE AUDIO FREQUENCY CURRENTS FLOWING THRU THE LOOP AND THE MIRROR WILL DEFLECT THE BEAM RAPIDLY TO ONE SIDE AND THE OTHER, THUS CAUSING THE LIGHT IMAGE ON THE FILM TO VARY IN WIDTH ACCORDING TO THE AUDIO FREQUENCIES WHICH ARE BEING RECORDED. THAT IS, THE SOUND TRACK WILL BE OF VARIABLE WIDTH AS ILLUSTRATED IN FIG.15.

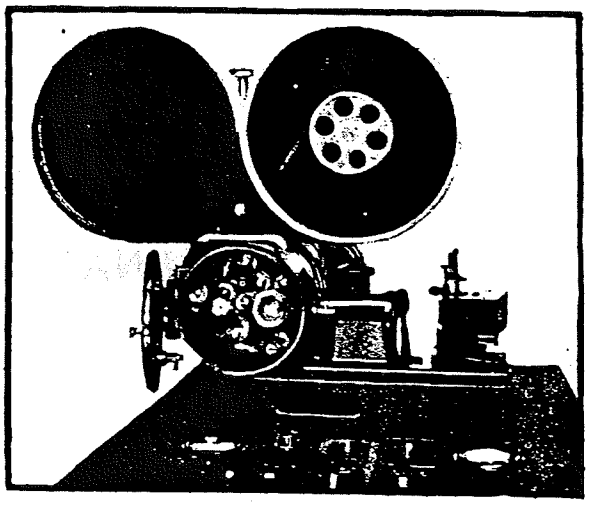

FIG.18
The Complete Assembled Recorder.

THE HOUSING AND ADJUSTMENT DETAILS FOR THE MOVEMENT, WHICH RECORDS THE LIGHT VARIATIONS ON THE FILM, ARE SHOWN IN FIG.17, WHEREAS THE MOVEMENT AND ITS ASSOCIATED APPARATUS IN THE COMPLETELY ASSEMBLED RECORDER IS SHOWN IN FIG.18.

IT REQUIRES SKILL TO ADJUST THE VARIABLE AREA TYPE OF RECORDER AS JUST DESCRIBED. THE WHOLE SYSTEM MUST BE LINED UP AND FOCUSED ACCURATELY, SO THAT THE BEAM OF LIGHT WILL FOLLOW THE PATHS INDICATED IN FIG. 16. THIS IS ACCOMPLISHED THROUGH THE USE OF A SERIES OF ADJUSTING SCREWS.

THE WIRE LOOP IS ROTATED BY ONE OF THESE ADJUSTMENTS AND IT IS SET, SO THAT THE LIGHT REFLECTED BY THE MIRROR COVERS JUST ONE-HALF OF THE SOUND TRACK. THE EDGE OF THIS LIGHT BEAM WILL THEN COINCIDE WITH AN INNER VERTICAL LINE ON THE SCALE, WHOSE POSITION IS SHOWN IN FIG. 16. WITH THE SYSTEM BEING MODULATED, THE AMPLIFIER GAIN MUST BE SO ADJUSTED THAT WITH THE MIRROR OSCILLATING, THE SPOT OF LIGHT SHOULD NOT EXTEND BE

YOND THE SCALE DURING THE LOUDEST PORTION OF THE RECORDING. IF IT DOES, THEN THE SYSTEM IS BEING "OVER-MODULATED", WHICH CONDITION WILL SPOIL THE TONE QUALITY.

IN RECORDING, THE PHOTOPHONE SYSTEM USES ONE MACHINE FOR PHOTOGRAPHY AND A SEPARATE MACHINE FOR SOUND RECORDING, EACH HAVING ITS OWN FILM BUT BEING SYNCHRONOUSLY DRIVEN. THE STARTING POINT OF EACH FILM IS MARKED; AND THEY ARE THEN COMBINED INTO ONE DURING THE DEVELOPING PROCESS, IN THE SAME MANNER AS DESCRIBED RELATIVE TO THE MOVIETONE SYSTEM. HERE, TOO, THE SOUND PRECEDES THE PICTURE BY ABOUT 14.5 INCHES, SO THAT THE TWO WILL BE REPRODUCED SIMULTANEOUSLY DURING PROJECTION OF THE FILM IN A THEATER.

IN THE PROJECTION OF SOUND AND SCENE WITH THE PHOTOPHONE SYSTEM, THE SAME PROCESSES ARE INVOLVED AS DESCRIBED RELATIVE TO THE MOVIETONE SYSTEM. THAT IS, THE SAME PROJECTOR CAN BE USED FOR EITHER SYSTEM, BUT THE LIGHT ENERGY STRIKING THE PHOTO-CELL THROUGH THE PHOTOPHONE SOUND TRACK, WILL VARY IN PROPORTION TO THE WIDTH OF THE SOUND TRACK AT ANY GIVEN POINT. THEN, SINCE THE WIDTH OF THE SOUND TRACK VARIES ACCORDING TO THE RECORDED AUDIO FREQUENCIES, THE LIGHT VARIATIONS PASSED BY IT WILL VARY AT CORRESPONDING FREQUENCIES; AND THE SAME IS TRUE WITH RESPECT TO THE PHOTO-CELL CURRENT. THEREFORE, BY MEANS OF THE SAME SOUND AMPLIFYING AND SPEAKER SYSTEM AS USED WITH MOVIETONE, WE CAN ALSO REPRODUCE THE SOUND RECORDING FROM PHOTOPHONE FILM.

EXAMINATION QUESTIONS

LESSON NO. SP-2

1. - IF A BATTERY AND A SERIES RESISTOR ARE CONNECTED ACROSS THE TERMINALS OF A PHOTO-ELECTRIC CELL SO THAT A POSITIVE POTENTIAL IS IMPRESSED UPON THE ANODE OF THIS PHOTO ELECTRIC CELL, THEN WHAT OCCURS IF A LIGHT OF INCREASING INTENSITY IS DIRECTED UPON THE CATHODE OF THE CELL?
2. - WHICH IS MORE SENSITIVE, A VACUUM TYPE PHOTO-ELECTRIC CELL OR A GAS-FILLED PHOTO-ELECTRIC CELL?
3. - IS THE SOUND TRACK ON THE MOVIETONE FILM OF THE CONSTANT DENSITY AND VARIABLE WIDTH TYPE?
4. - WHAT IS THE PURPOSE OF THE LIGHT VALVE IN THE MOVIETONE RECORDING SYSTEM?
5. - WHAT IS THE EXCITER LAMP OF A "SOUND-ON-FILM" PROJECTOR USED FOR?
6. - WHEN MAKING THE SOUND-ON-FILM RECORDING, IS THE SOUND RECORDED DIRECTLY UPON THE SAME FILM WHICH IS RECEIVING THE "PICTURE"?
7. - WHAT TYPE OF SOUND TRACK IS USED ON THE PHOTOPHONE TYPE FILM?
8. - EXPLAIN HOW THE SOUND CAN BE REPRODUCED DIRECTLY FROM THE SOUND FILM OF THE MOVIETONE SYSTEM AS RECORDING PROGRESSES?
9. - HOW ARE THE SOUND MODULATIONS RECORDED ON THE FILM OF THE PHOTOPHONE SYSTEM?
10. - CAN THE SAME MOTION PICTURE PROJECTOR BE USED FOR THE REPRODUCTION OF SOUND AND SCENE FROM EITHER A MOVIETONE OR PHOTOPHONE FILM? EXPLAIN.