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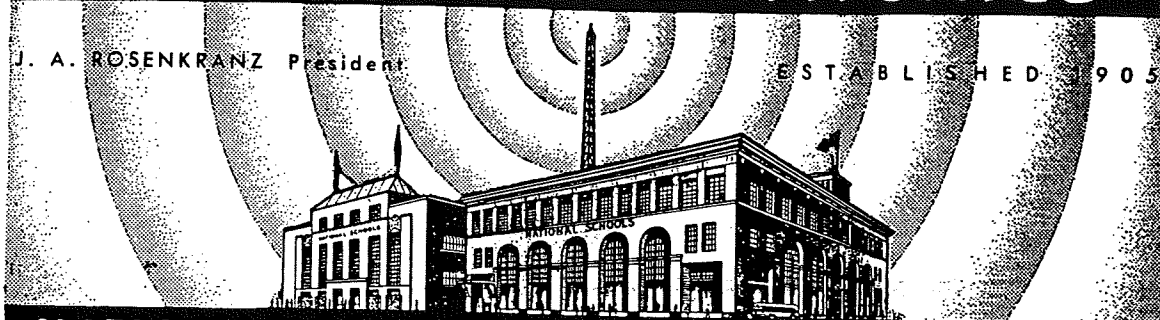
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Practical Technical Training In **RADIO·TELEVISION** AND ALLIED ELECTRONICS

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SOUND PICTURES

LESSON NO. SP - 1

DISC RECORDING

ALTHOUGH IT CAME INTO BEING ONLY A SHORT TIME AGO, THE MOTION PICTURE INDUSTRY, TODAY, IS ONE OF THE MAJOR INDUSTRIES OF THE WORLD.

THIS INDUSTRY, HOWEVER, HAD A HUMBLE BEGINNING, JUST LIKE MANY OTHER GREAT ENTERPRISES. EARLY PICTURES WERE BLURRY AND INDISTINCT BECAUSE THE EQUIPMENT USED AT THAT TIME WAS CRUDE, AND COMPARATIVELY LITTLE WAS KNOWN ABOUT THE ART OF PHOTOGRAPHY. BUT, AS YEARS PASSED CONTINUED DEVELOPMENT TOOK PLACE, NEW IDEAS WERE WORKED OUT, THE ASSOCIATED EQUIPMENT WAS PERFECTED AND, EVENTUALLY, REMARKABLE RESULTS WERE OBTAINED.

THE PICTURES, AS WE KNOW THEM TODAY, ARE CLEAR AND REALISTIC. THEY ARE SHOWN IN MAGNIFICENT THEATERS, AS WELL AS IN THE NEIGHBORHOOD "MOVIE", AND ARE AVAILABLE TO THE INHABITANTS OF THE SMALLEST OF TOWNS. HOWEVER, IN SPITE OF ALL THIS ASTOUNDING ADVANCEMENT IN THE ART OF PHOTOGRAPHY AND MOTION PICTURE PROJECTION SOMETHING WAS STILL LACKING -- THE

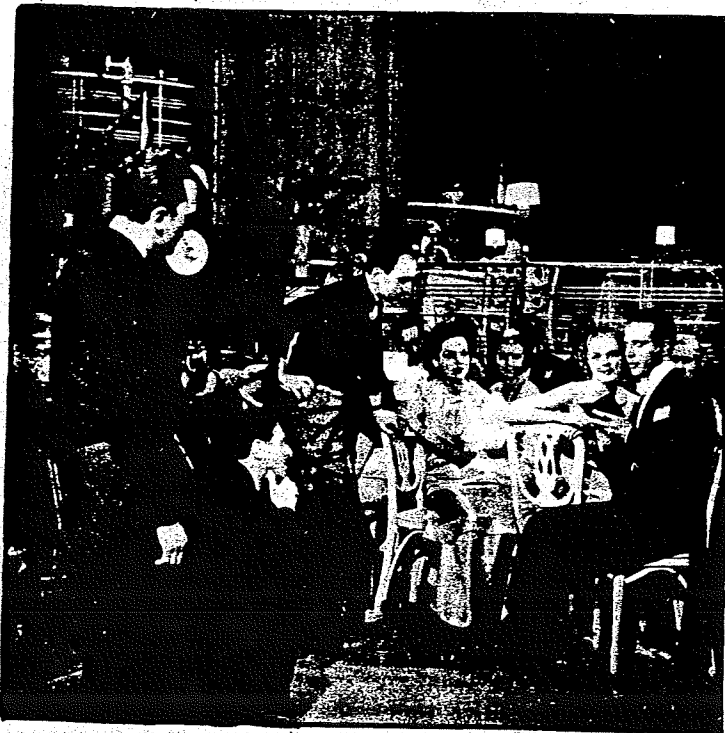


FIG. 1
RECORDING A SONG FOR A MUSICAL PICTURE

CHARACTERS DIDN'T SEEM EXACTLY ALIVE AS THEY WENT THROUGH THEIR MOTIONS AND GESTURES IN ABSOLUTE SILENCE. THE WHOLE THING, IN FACT, WAS JUST A MATTER OF PANTOMINE, WHEN ALL OF A SUDDEN, RADIO PRINCIPLES WERE INCORPORATED IN THE FILMING AND REPRODUCTION OF PICTURES AND GAVE US OUR MODERN SOUND PICTURES OF TODAY.

NO LONGER DO THE CHARACTERS MOVE ABOUT IN SILENCE OR AS SHADOWS BUT RADIO HAS PUT LIFE INTO THEM, SO THAT THE AUDIENCE ACTUALLY HEARS THE VARIOUS CONVERSATIONS, SONGS ETC., JUST AS THOUGH THE ACTORS WERE ON THE STAGE. WITHOUT THE PRINCIPLES OF RADIO, THE PRODUCTION OF TALKING PICTURES, AS THEY ARE MADE TODAY, WOULD BE AN IMPOSSIBILITY AND THEREFORE WE DO NOT EXAGGERATE WHEN WE MAKE THE STATEMENT THAT RADIO HAS REVOLUTIONIZED THE MOTION PICTURE INDUSTRY.

SINCE RADIO PRINCIPLES ARE SO ALL-IMPORTANT TO SOUND PICTURES, YOU WILL READILY REALIZE THAT MOST EVERYTHING WHICH YOU HAVE SO FAR LEARNED

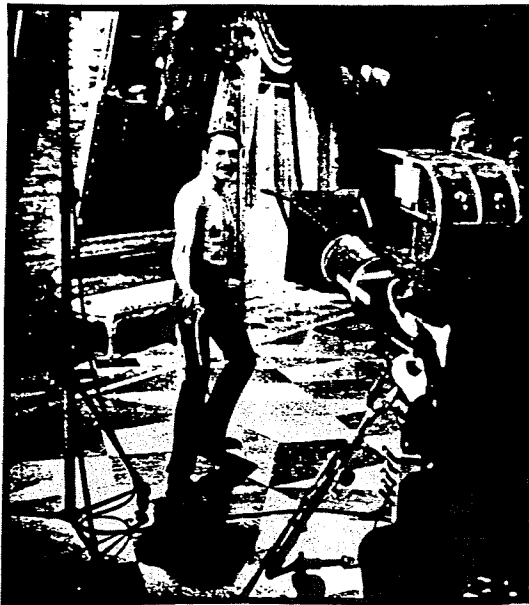


FIG. 2
Shooting a Scene.

REGARDING RADIO CAN BE APPLIED TO SOUND PICTURES. IN FACT, THE TRUTH OF THE MATTER IS THAT YOU HAVE ALREADY LEARNED THE GREATER AND MORE IMPORTANT PART OF THE TECHNICALITIES INVOLVED IN SOUND PICTURE WORK SO THAT IT IS NOW ONLY NECESSARY TO RELATE THESE VARIOUS PRINCIPLES TO THE "FILMING" PROCESSES INVOLVED. THERE ARE MANY ANGLES TO THE PRODUCTION AND REPRODUCTION OF SOUND PICTURES AND SO NATURALLY, IT WILL REQUIRE SEVERAL LESSONS IN WHICH TO DISCUSS SUCH A LARGE SUBJECT. IN EACH OF THESE SOUND PICTURE LESSONS, WE WILL DISCUSS CERTAIN PHASES OF THE PRODUCTION AND REPRODUCTION OF SOUND AND FILM, SO THAT UPON COMPLETING ALL OF THEM, YOU WILL HAVE A GOOD UNDERSTANDING OF THE WHOLE SUBJECT INCLUDING DISC RECORDING, FILM RECORDING, STUDIO TECHNIQUE, THE OPERATION OF "TALKIE" EQUIPMENT ETC.

IN THE FIRST LESSON OF THIS SERIES, WE WILL BEGIN WITH THE PROCESSES INVOLVED IN THE TYPE OF SOUND PICTURES, IN WHICH THE SOUND EFFECTS ARE RECORDED ON DISCS OR AS WE GENERALLY SAY, DISC RECORDING.

THE STAGE "SET-UP"

A PORTION OF THE SOUND RECORDING PROCESS IS QUITE SIMILAR TO THAT OF BROADCASTING. TO BEGIN WITH, THE SCENE IS CAREFULLY LAID OUT ON THE STAGE, THE ACTORS ASSUME THEIR RESPECTIVE POSITIONS, THE LIGHTING EFFECTS, CAMERAS ETC. ARE ADJUSTED SO THAT A PERFECT JOB OF PHOTOGRAPHY CAN BE ACCOMPLISHED. IN ORDER TO HAVE A PERFECT REPRODUCTION OF SOUND DURING THE FILMING, IT IS NECESSARY THAT THE SCENE BE ACOUSTICALLY TREATED, THE SAME AS IS DONE IN A BROADCASTING STUDIO, AND IN PICTURE WORK, THIS IS GENERALLY DONE BY LINING THE BACKGROUND OF THE SCENE WITH NON-RESONANT WOODEN SLABS, WHICH ARE KNOWN TO THE INDUSTRY AS "CELOTEX".

LARGE WOOLEN QUILTS ARE ALSO FREQUENTLY USED FOR SOUND ABSORPTION PURPOSES, SO AS TO REDUCE ECHOES AND OTHER ANNOYING SOUNDS.

THE MICROPHONE IS PLACED AT THE MOST STRATEGIC POINT, WHERE IT WILL FAITHFULLY PICK UP THE SOUND AS THE ACTORS MOVE ABOUT AND CARRY ON THEIR CONVERSATION ETC. AND VERY OFTEN, IT IS OF COURSE NECESSARY TO USE SEVERAL MICROPHONES AT THE SAME TIME. THIS IS ESPECIALLY TRUE WHEN "SHOOTING" A LARGE SCENE WHERE THE AREA TO BE COVERED IS TOO GREAT TO BE ADEQUATELY SERVED BY ONE MICROPHONE.

IN RESPECT TO MICROPHONE PLACEMENT, ONE MUST ALSO CONSIDER THE FACT THAT IT IS NOT PERMISSIBLE TO HAVE THE MICROPHONE SHOW IN THE PICTURE AND FOR THIS REASON, THE MICROPHONE IS GENERALLY PLACED ABOVE THE HEADS OF THE ACTORS, JUST HIGH ENOUGH TO BE EXCLUDED FROM THE RANGE OF THE CAMERA LENSE. IN FIG. 2, YOU WILL SEE SUCH AN EXAMPLE OF A SUSPENDED MICROPHONE, THE MICROPHONE IN THIS CASE BEING VISIBLE DIRECTLY ABOVE THE ACTOR'S HEAD, WHILE THE CAMERA CAN BE SEEN IN THE FOREGROUND.

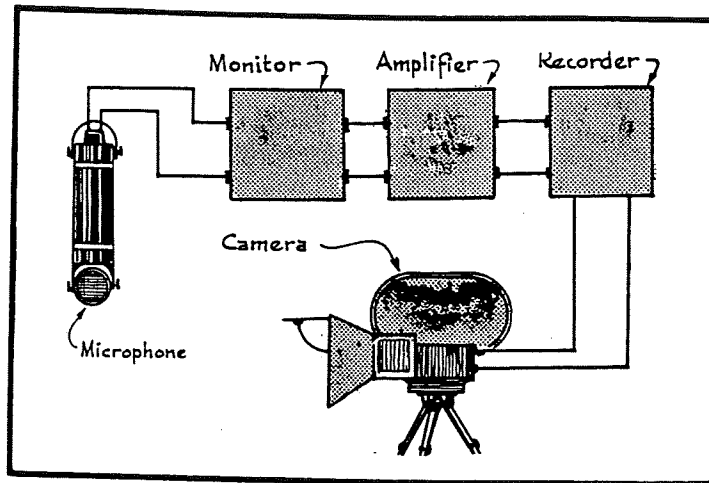


FIG. 3
Lay-out of the Recording Apparatus.

FOR THE PRESENT, WE ARE JUST CONSIDERING THE STUDIO OR STAGE "SET-UP" IN A BRIEF WAY, SIMPLY IN ORDER TO CARRY YOU THROUGH THE STEPS OF DISC RECORDING IN THE PROPER SEQUENCE BUT LATER, WE WILL DEAL WITH STUDIO TECHNIQUE IN GREATER DETAIL.

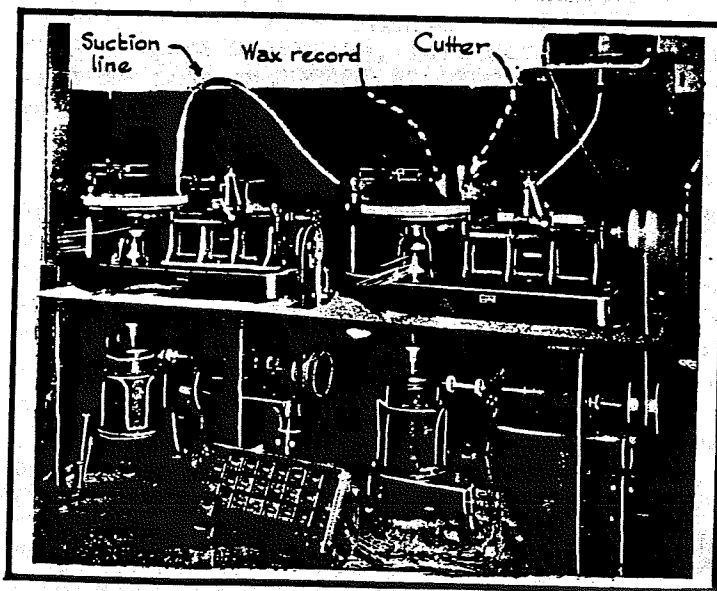


FIG. 4
Two Recording Units Driven Synchronously with Cameras.

THE RECORDING APPARATUS

IN FIG. 3, YOU WILL SEE A GENERAL LAY-OUT OF THE RECORDING APPARATUS AND THE CAMERA. THE MICROPHONE AND CAMERA ARE OF COURSE LOCATED ON THE SET (SCENE) WHILE THE MONITOR, AMPLIFIER AND RECORDER ARE LOCATED IN SOUND PROOF ROOMS OFF TO ONE SIDE OF THE STAGE OR SET KNOWN AS "MONITOR ROOMS" AND GENERALLY THEY ARE EQUIPPED WITH A THICK GLASS WINDOW, SO THAT THE OPERATORS CAN OBSERVE THE

ACTIONS GOING ON AS THEY OPERATE THEIR CONTROLS. THIS WOULD BE EQUIVALENT TO THE CONTROL ROOM OF A BROADCAST STATION WHILE THE SET CORRESPONDS TO THE BROADCAST STUDIO.

FOR SOUND RECORDING, THE MICROPHONE MUST BE OF A VERY HIGH QUALITY TYPE, AND THE MONITOR CONTROLS THE MICROPHONE OUTPUT RAISING OR LOWERING IT AS THE OPERATOR FINDS IT NECESSARY -- AT ALL TIMES BLENDING IT TO GIVE THE BEST EFFECTS POSSIBLE. THIS MONITOR IS ESSENTIALLY THE SAME AS THE MIXER USED FOR BROADCAST PURPOSES, AND WHICH WAS INTRODUCED TO YOU IN THE SERIES OF LESSONS TREATING WITH BROADCAST STATIONS.

FOLLOWING THE MONITOR, WE HAVE A HIGH GRADE AUDIO FREQUENCY AMPLIFIER OF CONVENTIONAL DESIGN BUT INSTEAD OF THIS AMPLIFIER'S OUTPUT OPERATING A SPEAKER, AS IN PUBLIC ADDRESS WORK, OR FEEDING INTO A TRANSMITTER CIRCUIT AS IN A BROADCAST SYSTEM, THE AMPLIFIER OF THE SOUND RECORDING SYSTEM IS USED TO OPERATE A RECORDER.

WHEN USING MORE THAN ONE MICROPHONE, AS IS OFTEN THE CASE, THEN THE VARIOUS MICROPHONES CAN ALL BE FED INTO A MIXER, THE SAME AS IN RADIO

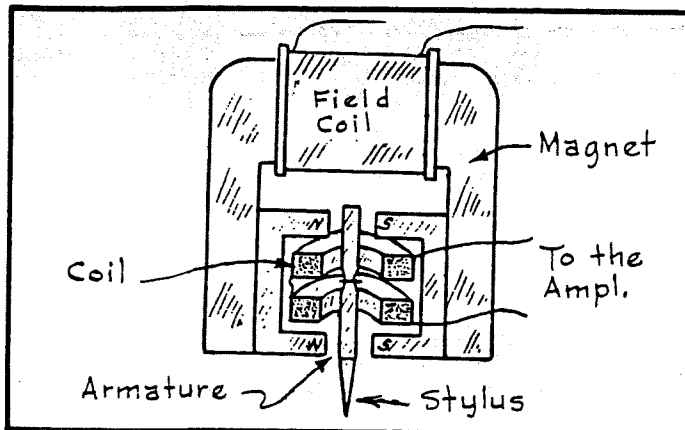


FIG. 5.

The Recording Unit.

PRACTICE, SO THAT ANY ONE OR ALL OF THEM CAN BE CUT IN AND OUT OF OPERATION AS NEEDED AND IF IT IS NECESSARY TO HAVE THE MICROPHONES LOCATED AT A CONSIDERABLE DISTANCE FROM THE MIXER AND AMPLIFIER, THEN AN INTERMEDIATE OR LINE AMPLIFIER CAN BE INSTALLED IN THE CIRCUIT BETWEEN THE MONITOR AND MICROPHONE OUTPUT SO AS TO PREVENT TOO GREAT A LOSS OF MICROPHONE ENERGY.

IN FIG. 4, YOU WILL SEE TWO RECORDING MACHINES MOUNTED SIDE BY SIDE. FUNDAMENTALLY, THEY ARE NOTHING MORE THAN A PAIR OF HIGH GRADE LATHES, EACH PROVIDED WITH A TURNTABLE WHICH CORRESPONDS TO THE TURN TABLE ON A PHONOGRAPH. THESE RECORDING MACHINES ARE ARRANGED TO BE DRIVEN SYNCHRONOUSLY WITH THE CAMERA. THAT IS, THE SPEED OF THE TURN TABLE AND THE LATERAL MOTION OF THE RECORDING UNIT (RECORDER CUTTER) MUST BE PROPERLY TIMED WITH THE SPEED AT WHICH THE RIBBON TYPE FILM IS BEING UNREELLED THRU THE CAMERA. THIS MUST BE DONE IN ORDER TO KEEP THE SOUND AND FILM IN STEP WITH EACH OTHER, AS OTHERWISE THE ACTOR'S MOTIONS WOULDN'T CORRESPOND WITH THE WORDS THAT HE IS SPEAKING AND THIS WOULD NATURALLY SPOIL THE RECORDING.

ALTHOUGH ONLY ONE CAMERA IS SHOWN IN FIG. 3, YET IT IS A COMMON PRACTICE TO "SHOOT" THE SCENE WITH SEVERAL CAMERAS AT THE SAME TIME. IN THIS CASE, THE CAMERAS CAN BE CONSIDERED AS BEING OPERATED IN PARALLEL, ALL OF THEM BEING SYNCHRONIZED TO THE SPEED OF THE RECORDING MACHINE.

THE RECORDING UNIT

NOW IN FIG.5, WE HAVE A SIMPLE DIAGRAM, ILLUSTRATING THE FUNDAMENTAL PRINCIPLE WITH WHICH A RECORDING UNIT CAN BE MADE TO OPERATE. NOTICE THAT WE HAVE A PIECE OF SOFT IRON BENT INTO THE SHAPE OF A HORSESHOE. A PAIR OF "U" SHAPED POLE PIECES ARE THEN MOUNTED TO THIS LARGE MAGNET, SO THAT WE HAVE A PAIR OF NORTH POLES ON ONE SIDE AND A PAIR OF SOUTH POLES ON THE OTHER. THIS MAGNET IS ENERGIZED BY A FIELD COIL THROUGH WHICH A D.C. SUPPLY IS FLOWING.

AT THE CENTER, WE HAVE A LIGHT METAL (IRON) ARMATURE, WHICH IS FLEXIBLY PIVOTED AT ITS CENTER AND A SHARP CUTTING TOOL MADE OF FINELY GROUND SAPHIRE, PROPERLY CALLED A STYLUS, IS MOUNTED ON THE LOWER END OF THIS ARMATURE. THE ARMATURE IS NORMALLY BALANCED DUE TO THE EFFECT OF THE NORTH AND SOUTH POLES UPON IT, CONSEQUENTLY, ITS NORMAL POSITION LIES IN A VERTICAL PLANE AS ILLUSTRATED IN FIG.5.

A "VOICE COIL", MADE UP IN TWO SECTIONS, SURROUNDS THE ARMATURE IN THIS PARTICULAR EXAMPLE AND THE ENDS OF THIS "VOICE COIL" ARE CONNECTED TO THE OUTPUT TERMINALS OF THE AUDIO AMPLIFIER. THEREFORE, AS THE VARYING CURRENTS OF SOUND FREQUENCY FLOW THROUGH THIS COIL, THE MAGNETIC REACTION WILL BE SUCH AS TO CAUSE THE ARMATURE TO OSCILLATE OR ROCK TO AND FRO ON ITS PIVOT AND IN STEP WITH THE A.F. CURRENT VARIATIONS. IN GENERAL RESPECTS, THIS UNIT IS QUITE SIMILAR TO A BALANCED ARMATURE TYPE SPEAKER UNIT, ONLY THAT INSTEAD OF TRANSFERRING THE ARMATURE MOTION TO A SPEAKER DIAPHRAGM, THIS MOTION IS USED TO MOVE THE STYLUS FROM SIDE TO SIDE IN DIRECT RELATION TO THE AUDIO FREQUENCY VARIATIONS THROUGH THE "VOICE COIL".

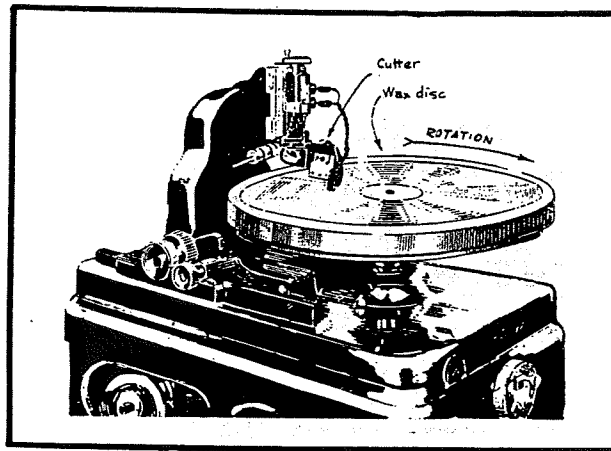


FIG. 6
Cutting the Wax.

SO FAR, YOU CAN SEE HOW IT IS POSSIBLE TO MAKE A CUTTING TOOL VIBRATE IN A DIRECT RELATION TO THE AUDIO FREQUENCIES, WHICH ARE IMPRESSED UPON THE DIAPHRAGM OF A MICROPHONE, REGARDLESS OF WHETHER THE SOUND BE MUSIC, SPEECH, OR JUST NOISE. THE THING TO DO NOW IS TO TRANSFER THIS MOTION OF THE STYLUS OR CUTTING TOOL TO SOME SUITABLE MATERIAL, SO THAT IT WILL CUT IMPRESSIONS IN IT, CORRESPONDING EXACTLY TO THE VIBRATIONS WHICH THE ARMATURE OF THE RECORDING TOOL UNDERGOES. WE THEN HAVE A RECORD OF THE STYLUS VIBRATIONS, AS WELL AS OF THE AUDIO FREQUENCIES CAUSING THESE SAME VIBRATIONS. LET US NOW PROCEED AND SEE HOW THIS IS DONE IN PRACTICE.

CUTTING THE WAX

TO BEGIN WITH, IT IS OBVIOUS THAT THE SUBSTANCE, INTO WHICH THESE SOUND IMPRESSIONS ARE TO BE CUT, MUST BE SOFT ENOUGH SO AS TO PERMIT

THE ARMATURE AND CUTTING TOOL OF THE RECORDING UNIT TO HAVE FULL FREEDOM OF MOTION. THE SUBSTANCE USED FOR THIS PURPOSE CONSISTS OF STEARIN, MONTAN WAX AND EITHER LEAD OR ALUMINUM. GREAT CARE MUST BE EXERCISED THAT IT WILL BE OF THE CORRECT DENSITY AND FREE FROM GRIT AND AIR HOLES. THIS IS GENERALLY REFERRED TO AS A "WAX" AND IT IS SHAPED INTO DISCS, WHICH ARE FROM ONE TO TWO INCHES THICK AND FROM THIRTEEN TO SEVENTEEN INCHES IN DIAMETER.

BEFORE RECORDING ON THIS DISC OR WAX, IT MUST FIRST BE PLACED IN A LATHE AND SHAVED TO A HIGHLY POLISHED SURFACE. THE WAX IS THEN PLACED ON THE TURN TABLE OF THE RECORDING MACHINE AS SHOWN IN FIG. 6 AND AS THE RECORD IS ROTATED BY THE TURN TABLE, THE RECORDING UNIT IS GRADUALLY CAUSED TO TRAVEL IN A STRAIGHT LINE ALONG A HORIZONTAL PLANE AS INDICATED BY THE ARROW IN FIG. 6.

THUS IF THE STYLUS OR CUTTING TOOL BEARS DOWN UPON THE WAX WITH SUFFICIENT PRESSURE, IT CAN BE SEEN THAT A SPIRAL GROOVE IS CUT INTO THE WAX SURFACE STARTING AT THE CENTER AND FINALLY ENDING UP AT ITS RIM. IN MODERN RECORDING PRACTICE, THIS GROOVE IS KEPT AT A CONSTANT DEPTH AND WITHOUT ANY MODULATING CURRENT FLOWING THROUGH THE COIL OF THE RECORDER, IT CAN BE SEEN THAT THIS PROCESS WILL PROVIDE A UNIFORM SPIRAL GROOVE WHICH ONLY FORMS A "TRACK", SO TO SPEAK, BUT DOES NOT RECORD ANY SOUND.

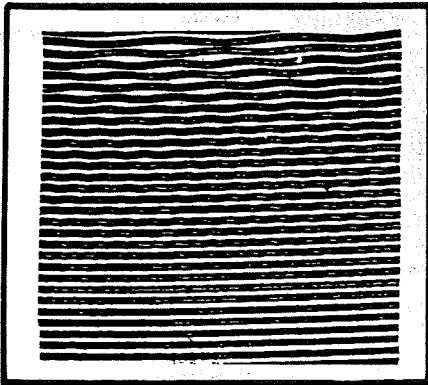


FIG. 7
Modulated Recording Grooves.

CUT INTO THE WAX, THESE GROOVES WILL HAVE IRREGULARITIES CUT IN EACH OF THEIR SIDES SOMEWHAT AS ILLUSTRATED BY THE HIGHLY MAGNIFIED REPRESENTATIONS IN FIGS. 7 AND 8.

THE WAVY PORTIONS IN THE GROOVE ARE THE AUDIO FREQUENCY MODULATIONS, WHICH ARE RECORDED ON THE WAX AND THEY ARE AN EXACT REPRODUCTION OF THE AUDIO FREQUENCIES, WHICH ARE IMPRESSED UPON THE MICROPHONE OF THIS RECORDING SYSTEM. IN OTHER WORDS, INSTEAD OF USING THE AUDIO FREQUENCIES IN A SPEAKER UNIT TO PRODUCE IMPRESSIONS ON THE SURROUNDING AIR AND THEREBY DELIVER SOUND TO OUR EARS, WE SIMPLY USE THIS ENERGY TO CUT CORRESPONDING IMPRESSIONS INTO A WAX DISC. LOW FREQUENCIES WILL PRODUCE A LONG WAVY IMPRESSION, WHEREAS THE HIGHER FREQUENCIES HAVE THEIR IRREGULAR IMPRESSIONS CROWDED CLOSELY TOGETHER. THE COMMERCIAL TYPE PHONOGRAPHS HAVE THEIR RECORDS CUT SO THAT THE RECORDING IS STARTED AT THE RIM OF THE RECORD AND IS ENDED AT THE CENTER. THE RECORDINGS FOR TALKING PICTURES AND EVEN FOR RECORDED BROADCAST PROGRAMS ARE JUST THE OPPOSITE IN THIS RESPECT BECAUSE IN THESE CASES, THE RECORDING IS STARTED AT THE CENTER OF THE DISC AND CONCLUDED AT THE RIM.

A DETAILED DRAWING OF THE STYLUS POINT, AS USED IN THE "VITAPHONE

SYSTEM", IS SHOWN IN FIG. 9. AT THE LEFT OF THIS ILLUSTRATION, YOU ARE GIVEN THE DIMENSIONS OF THE GROOVE, AS MADE IN THE WAX, AND AS YOU WILL NOTE, IT IS 0.006" WIDE AND 0.0025" DEEP AND THE SPACE BETWEEN THE EDGES OF THE GROOVES IS ABOUT .004". THIS LEAVES A MAXIMUM SAFE AMPLITUDE OF ABOUT .002" AND IF THIS IS REACHED AT 250 CYCLES, THEN THE CORRESPONDING AMPLITUDE AT 5,000 CYCLES IS ONLY .0001", PROVIDED THAT THE SOUND IS CONSTANT IN ABSOLUTE INTENSITY OVER THE INTERVENING RANGE.

THE WAX DISC MUST BE LEVELED IN THE RECORDING MACHINE WITH REASONABLE CARE AND THE STYLUS MUST BE SHARP AND OF A SHAPE TO INSURE A CLEAN CUT. TO AID IN MAINTAINING THE CUT AT THE CORRECT DEPTH, A SO CALLED "ADVANCE BALL" RIDES LIGHTLY OVER THE SURFACE OF THE DISC, SUPPORTING THE STYLUS AT THE PROPER HEIGHT IN SPITE OF SMALL INACCURACIES IN LEVELLING THE DISC OR DEVIATIONS FROM FLANENESS. FOR ADJUSTING THE ADVANCE BALL WITH RESPECT TO THE STYLUS, THE GROOVE IS OBSERVED WITH A CALIBRATED MICROSCOPE AND AS THE CUT IS MADE IN THE DISC, THE WAX SHAVING IS IMMEDIATELY REMOVED BY AIR SUCTION. IN FIG. 10 YOU ARE SHOWN HOW A MICROSCOPIC EXAMINATION IS BEING MADE OF THE WAX AS IT IS BEING CUT.

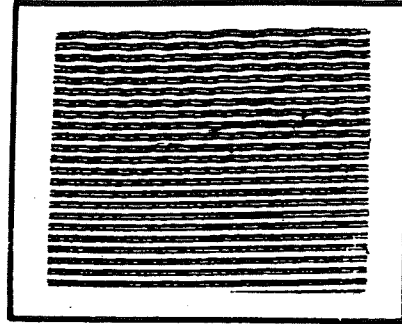


FIG. 8

A Complex Recording.

IN THE RECORDS USED WITH THE WESTERN ELECTRIC APPARATUS, THE LINEAR SPEED OF THE GROOVE PAST THE REPRODUCER POINT RANGES FROM 140 FT. PER MINUTE AT THE OUTSIDE OF THE SPIRAL TO 70 FT. PER MINUTE AT THE INSIDE. THE RATE OF ROTATION IS OF COURSE DEPENDENT UPON THE OUTER DIAMETER OF THE GROOVES, WHICH IS DETERMINED PRIMARILY BY THE LENGTH OF TIME TO BE COVERED BY A SINGLE DISC.

DO NOT FORGET, HOWEVER, THAT THE CAMERA AND THE TURNTABLE OF THE RECORDING MACHINE MUST BEAR A DEFINITE RELATION TO EACH OTHER AS REGARDS THEIR OPERATING SPEED AND THAT A COMMON DRIVING MOTOR IS FREQUENTLY EMPLOYED FOR THESE TWO UNITS AND IN THIS CASE THE CAMERAS ARE CONTAINED WITHIN SOUND PROOF BOOTHS THE SAME AS THE RECORDING MACHINES. BY MEANS OF GEARS, SUCH A MACHINE RUNNING AT A CONSTANT SPEED OF USUALLY 1200 R.P.M. MAY BE MADE TO TAKE THE RIBBON-LIKE FILM THROUGH THE CAMERA AT A STANDARD SPEED OF 90 FT. PER MINUTE, WHILE THE TURN TABLE OF THE RECORDING MACHINE REVOLVES AT 33 R.P.M. BY CONTINUALLY MAINTAINING THESE SPEED RELATIONS, THE SOUND EFFECTS UPON THE RECORD WILL BE SYNCHRONIZED WITH THE FILM.

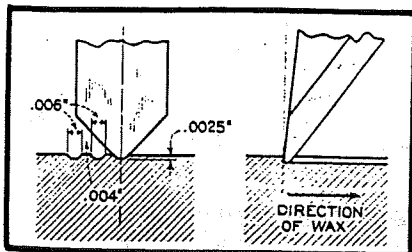


FIG. 9

Details of the Cut.

IF IT IS DESIRED TO SEPARATE THE SOUND AND PICTURE RECORDERS, THEN INDIVIDUAL MOTORS ARE USED, WHICH ARE USUALLY OF THE SYNCHRONOUS ALTERNATING CURRENT TYPE. BY MEANS OF USING "FADERS" WITH THE AMPLIFIER, THE RECORDING CAN BE CONTINUED ON ANOTHER WAX WHEN ONE OF THE RECORDS IS CUT AND IF CAREFULLY DONE, THIS CHANGEVER WILL PRODUCE NO NOTICEABLE EFFECT.

USE OF THE PLAYBACK ON THE WAX DISC

AFTER A RECORD HAS BEEN CUT, THE SOUND MAY BE REPRODUCED DIRECTLY FROM THE WAX BY MEANS OF A SUITABLE PICKUP OR REPRODUCER BUT THE ORDINARY TYPE OF REPRODUCERS REST TOO HEAVILY ON THE RECORDS. AS A MATTER OF FACT, THE VERTICAL PRESSURE BETWEEN THE NEEDLE POINT AND THE RECORD IN AN ORDINARY PHONOGRAPH IS APPROXIMATELY 50,000 LBS. PER SQUARE INCH. THESE HIGH PRESSURES HAVE BEEN NECESSARY IN THE PAST IN ORDER THAT THE RADIAL MOTION OF THE NEEDLE WOULD BE OF THE PROPER MAGNITUDE AS IT PASSES THROUGH THE MODULATED GROOVE OF A FINISHED RECORD. OBVIOUSLY, SUCH PRESSURES WOULD DESTROY A GROOVE IN WAX AND ANY REDUCTION IN THIS NEEDLE PRESSURE MUST THEREFORE BE ACCOMPANIED BY A REDUCTION IN THE MASS AND STIFFNESS OF THE REPRODUCER.



FIG. 10

Microscopic Examination of the Record.

SO IN ORDER TO MEET THESE CONDITIONS, SPECIAL "PLAYBACKS", AS THE REPRODUCERS ARE

CALLED, HAVE BEEN DEVELOPED SO THAT THE SOUND CAN BE REPRODUCED FROM THE ORIGINAL WAX RECORD WITH PRACTICALLY THE SAME QUALITY AS OBTAINED WHEN USING THE BEST TYPE OF ELECTRIC PICK UP WITH THE FINISHED RECORD. SUCH A SPECIAL "PLAYBACK" IS SHOWN IN FIG. 11 AND THROUGH ITS USE, THE QUALITY OF THE RECORDING CAN BE JUDGED AND PASSED UPON BEFORE GOING THROUGH THE FOLLOWING PROCEDURES WITH ITS ACCOMPANYING EXPENSE. IN OTHER WORDS, IF THE RECORDING DOES NOT COME UP TO STANDARD, IT CAN BE DONE OVER AGAIN BEFORE EVER PASSING IT THROUGH THE FINISHING PROCESSES.

MAKING THE MASTER RECORD

AFTER THE WAX RECORDING IS PRONOUNCED AS BEING O.K. IT IS TAKEN TO THE "GALVANO BATHS" AND DURING THIS TRANSPORTATION GREAT CARE MUST BE EXERCISED SO THAT THE DELICATE GROOVES ON THE WAX ARE NOT MARRED. THE USUAL PROCEDURE AT THIS TIME IS TO BRUSH A SPECIAL FINE POWDER OVER THE GROOVED-SIDE OF THE WAX. THIS POWDER HAS THE IMPORTANT PROPERTY OF BEING A GOOD CONDUCTOR FOR AN ELECTRIC CURRENT AND BECAUSE OF THIS, IT IS KNOWN TO THE INDUSTRY AS "CONDUCTING POWDER".

THE TREATED WAX IS NOW ATTACHED TO THE END OF A LONG ARM, WHICH SWI-

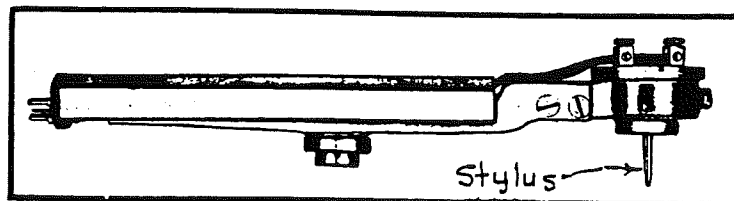


FIG. 11

A "Playback" for Reproduction from Wax Discs.

SHES IT BACK AND FORTH THROUGH THE "BATH" OR ELECTROPLATING SOLUTION AND GRADUALLY A COPPER COATING WILL FORM ON THE CUT SIDE OF THIS DISC, WHICH FINALLY TURNS INTO A COPPER PLATE. THIS COPPER PLATE IS CALLED THE "MASTER" AND WHEN IT IS PEELED FROM THE WAX DISC, IT IS A "NEGATIVE". THAT IS, THE ORIGINAL RECORDING GROOVES ARE NOW DUPLICATED ON THE COPPER PLATE IN THE FORM OF LINES, WHICH ARE RAISED ABOVE THE SURFACE. IN FIG.12 YOU ARE SHOWN THE ELECTROPLATING TANKS AT ONE OF THE MAJOR STUDIOS.

THE TEST PRESSINGS

THE COPPER MASTER IS THEN PLACED IN A HUGE PRESS, PREPARATORY TO MAKING A PAIR OF TEST PRESSINGS. THESE PRESSINGS ARE MADE OF A COMBINATION EARTH AND SHELLAC MATERIAL, WHICH IS HEATED TO THE CONSISTENCY OF DOUGH AND PLACED WITH THE MASTER. THEN UNDER ENORMOUS HEAT AND PRESSURE, THE RECORDING LINES OF THE MASTER ARE IMPRINTED INTO THE TEST PRESSINGS SO THAT THE TEST PRESSINGS ARE DUPLICATES OF THE WAX RECORDING.

THE TEST PRESSINGS ARE THEN PLAYED WITH A PHONOGRAPH PICK UP AND IF UP TO STANDARD, THE FOLLOWING PROCESSES ARE NOW IN ORDER. IT SEEMS LOGICAL THAT THE FINAL PRESSINGS CAN NOW BE MADE FROM THE MASTER BUT THIS IS NOT DONE IN PRACTICE. THE REASON FOR THIS IS THAT IF IN THE PRESSING PROCESS, THE MASTER SHOULD FOR SOME REASON OR OTHER BE MARRED, NO IMPRESSION OF THE ORIGINAL RECORDING WOULD REMAIN FROM WHICH MORE PRESSINGS COULD BE MADE. YOU WILL REMEMBER THAT THE WAX HAS ALREADY BEEN SPOILED WHEN THE MASTER WAS TAKEN FROM IT AND THE WAX HAS BY THIS TIME PROBABLY ALREADY BEEN SHAVED AND IS ONCE MORE READY FOR USE IN RECORDING ADDITIONAL PARTS OF THE PICTURE.

THE MOTHER AND STAMPER

FOR THE ABOVE MENTIONED REASONS, THE MASTER IS NOW ELECTROPLATED AND THE RESULTING COPPER DISC IS CALLED THE "MOTHER". THE "MOTHER" THUS BECOMES AN EXACT DUPLICATE OF THE ORIGINAL WAX AND WITH THIS DONE, THE MASTER IS CAREFULLY FILED AWAY FOR EMERGENCY OR FOR FITTING FUTURE ORDERS OF THE SAME PORTION OF THE PICTURE RECORDING. THE "MOTHER" IS THEN IN TURN ELECTROPLATED AND THE NEGATIVE COPPER DISC, WHICH THIS PROCESS PRODUCES, IS CALLED THE "STAMPER".



FIG. 12
The Electroplating Room.

THE "STAMPER" IS THEN CAREFULLY GROUND AND BUFFED AND OTHERWISE PREPARED. IT IS THEN PLACED IN THE PRESS, TOGETHER WITH THE EARTH-SHELLAC MATERIAL AND THUS THE FINAL DISCS ARE PRESSED OUT TO THE DESIRED NUMBER. IF MANY PRESSINGS ARE NEEDED, THEN SEVERAL STAMPERS ARE MADE BECAUSE THE USE OF ONE STAMPER FOR TOO MANY PRESSINGS LESSENS THE CLARITY AND SHARPNESS OF THE DISCS AFTER A TIME. HOWEVER, IT IS NOT UNUSUAL TO MAKE A THOUSAND PRESSINGS FROM A SINGLE STAMPER.

THE FINISHED RECORDS LOOK JUST LIKE THE ORDINARY DISC TYPE PHONOGRAPH RECORDS ONLY THAT THEY ARE LARGER IN DIAMETER AND THE RECORDING STARTS AT THE CENTER AND IS ENDED NEAR THE RIM OF THE RECORD. THE POINT AT WHICH THE RECORDING STARTS IS MARKED, GENERALLY WITH A WHITE LINE, SO THAT THIS POINT CAN BE DETERMINED READILY DURING PRODUCTION.

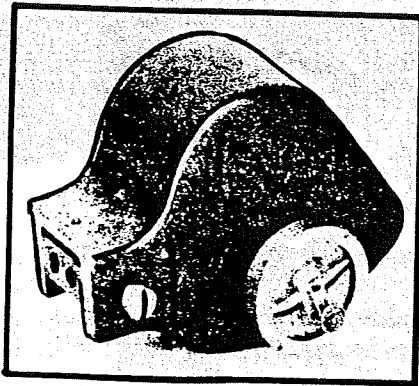


FIG. 13
*The Western Electric
Reproducer.*

IT IS OF COURSE UNDERSTOOD THAT MANY RECORDS GO TOGETHER, IN ORDER TO MAKE UP THE COMPLETE SOUND RECORDING OF THE PICTURE. THESE FOLLOW EACH OTHER IN CONSECUTIVE ORDER, WITH ONE BEGINNING WHERE THE OTHER LEFT OFF.

PICK-UP UNITS

IN A PREVIOUS LESSON TREATING WITH RADIO-PHONOGRAPH COMBINATIONS, YOU LEARNED ABOUT THE ELECTROMAGNETIC TYPE PHONOGRAPH PICK-UP UNIT AND THEREFORE IT WILL NOT BE NECESSARY TO REPEAT ANY INSTRUCTION REGARDING IT AT THE PRESENT TIME. BY PLACING A SOUND PICTURE RECORD ON A TURNTABLE, PERMITTING THE PICK-UP UNIT TO RIDE THE GROOVE AND CONNECTING THE PICK-UP ACROSS THE INPUT TERMINALS OF AN A.F. AMPLIFIER, THE RECORDED SOUNDS CAN BE REPRODUCED.

ALTHOUGH IT IS ACTUALLY POSSIBLE TO USE AN ELECTROMAGNETIC PICK-UP UNIT IN THE MANNER JUST DESCRIBED, YET IN ACTUAL PRACTICE, PICK-UP DEVICES OF HIGHER QUALITY ARE USED FOR SOUND PICTURE WORK. THIS SHALL NOW BE EXPLAINED.

OIL-DAMPED PICK-UP

THE ELECTROMAGNETIC PICK-UPS WHICH ARE USED FOR SOUND PICTURE WORK, AS WELL AS FOR THE REPRODUCTION OF ELECTRICAL TRANSCRIPTION RADIO BROADCASTS AND OTHER USES WHERE HIGH QUALITY REPRODUCTION IS REQUIRED, ARE GENERALLY OF THE OIL-DAMPED DESIGN. A PICK-UP HEAD OF THIS TYPE IS SHOWN IN FIG. 13 AND ITS INTERNAL CONSTRUCTION IS ILLUSTRATED IN FIG. 14.

BY STUDYING FIG. 14 CLOSELY YOU WILL NOTICE THAT THE NEEDLE IS ATTACHED TO A METAL DIAPHRAGM MADE OF TORSION-STEEL AND WHICH IS MAGNETICALLY CONNECTED TO ONE POLE OF THE FIELD MAGNET. THE OTHER POLE OF THE MAGNET TERMINATES IN A SHOE WHICH CONSISTS OF TWO BRANCHES OR FORKS AND UPON WHICH ARE MOUNTED THE PICK-UP COILS. THIS FORM OF CONSTRUCTION SHORTENS MATERIALLY THE LENGTH OF THE PATH FOR THE FLUX THROUGH NON-MAGNETIC MATERIAL AND THEREBY INCREASES THE FLUX DENSITY AS WELL AS THE MAGNETIC LIFE.

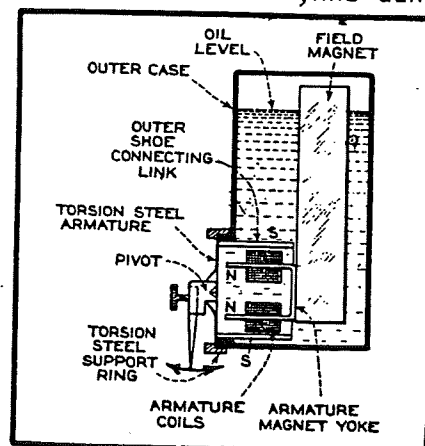


FIG. 14
*Construction of Oil-damped
Pick-up.*

WHEN THE NEEDLE IS CENTERED OR IN ITS NEUTRAL POSITION, THEN THE FLUX DENSITY BETWEEN THE DIAPHRAGM AND BOTH OF THE COIL SUPPORTS IS EQUAL. THEN AS THE NEEDLE MOVES FROM SIDE TO SIDE THE DIAPHRAGM IS DISTORTED IN AN S-SHAPE SO AS TO BE NEARER ONE OF THE COIL SUPPORTS AND FARTHER FROM THE OTHER. THIS CAUSES A RE-DISTRIBUTION OF THE FLUX, RESULTING IN AN INCREASE IN LINES OF FORCE PAST THE COIL WHICH IS MOUNTED ON THE SUPPORT NEAREST THE DIAPHRAGM AND A REDUCTION IN THE LINES OF FORCE PAST THE OTHER COIL.

THIS CHANGE IN FLUX DENSITY AT BOTH COILS CAUSES AN E.M.F. TO BE INDUCED IN EACH OF THEM AND SINCE THE TWO COILS ARE CONNECTED IN SERIES THE TWO E.M.F'S ARE ADDED TOGETHER. THEN WHEN THE NEEDLE IS DEFLECTED IN THE OPPOSITE DIRECTION BY THE GROOVE IN THE RECORD, THE DIAPHRAGM IS ALSO DISTORTED IN THE OPPOSITE DIRECTION CAUSING THE INDUCED E.M.F'S IN THE COILS ALSO TO BE REVERSED. THUS WE HAVE A COMPLETE A.C. CYCLE FOR EACH COMPLETE SWING OF THE NEEDLE.

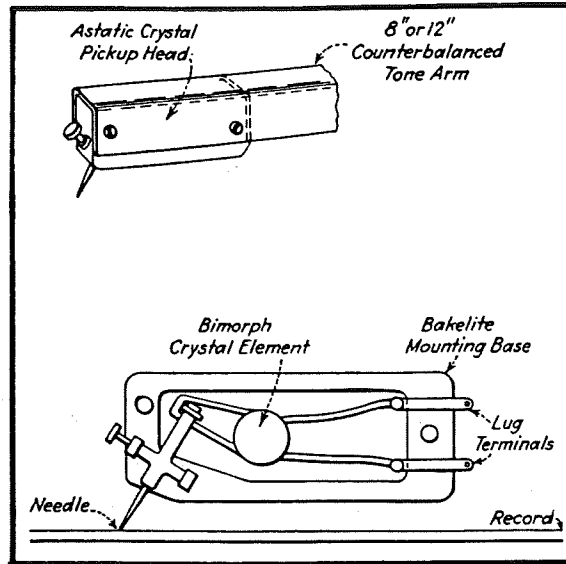


FIG. 15
The Crystal Type Pick-up Head.

SO AS TO PROVIDE A STILL GREATER DAMPING EFFECT THAN THAT FURNISHED BY THE STRESS OF THE DIAPHRAGM ALONE, THE ENTIRE ASSEMBLY IS ENCLOSED IN A CASE WHICH IS FILLED WITH OIL. THIS OIL WILL EXERT A PRESSURE AGAINST THE DIAPHRAGM AND THEREBY INCREASE THE DAMPING EFFECT.

THIS TYPE OF CONSTRUCTION IN ADDITION TO SUPPLYING A FAIRLY CONSTANT FREQUENCY CHARACTERISTIC, IS STURDY IN CONSTRUCTION AND CAPABLE OF LONG LIFE.

THE CIRCUIT CONNECTIONS FOR THIS TYPE OF PICK-UP ARE EXACTLY THE SAME AS HAVE ALREADY BEEN DESCRIBED TO YOU IN PREVIOUS LESSONS AND RELATIVE TO ELECTROMAGNETIC PICK-UPS IN GENERAL.

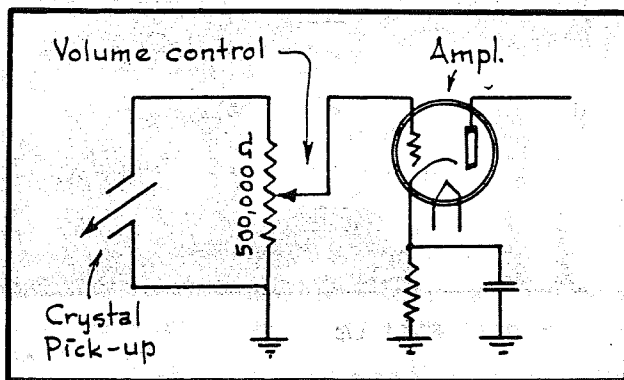


FIG. 16
Crystal Pick-up Connection.

THE CRYSTAL PICK-UP

FROM WHAT YOU HAVE ALREADY LEARNED ABOUT PIEZO-ELECTRIC CRYSTALS AND THEIR NUMEROUS APPLICATIONS, YOU WILL READILY REALIZE THAT IT IS POSSIBLE TO USE SUCH CRYSTALS IN PICK-UP DEVICES. IN OTHER WORDS, IF THE MECHANICAL VIBRATIONS OF THE PICK-UP NEEDLE ARE TRANSFERRED TO A PIEZO-ELECTRIC CRYSTAL, THE CRYSTAL CAN INTURN GENERATE VOLTAGE CHANGES THE

SAME AS OCCURS IN CRYSTAL MICROPHONES.

THE INTERNAL CONSTRUCTION OF A TYPICAL CRYSTAL PICK-UP, OR PIEZO-ASTATIC TYPE PICK-UP AS IT IS FREQUENTLY CALLED, IS SHOWN IN FIG.15. HERE YOU WILL OBSERVE THAT THE CRYSTAL AND NEEDLE ARE MECHANICALLY INTERCONNECTED THROUGH A "DRIVING MEMBER" AND THAT THE CRYSTAL SURFACES ARE CONNECTED ACROSS THE OUTPUT TERMINALS OF THE UNIT.

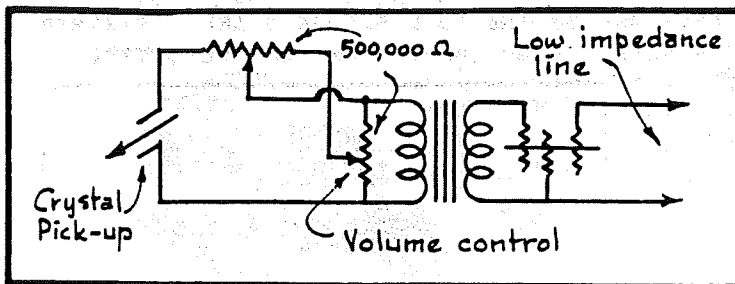


FIG. 17
Pick-up Connection With Long Line.

CONNECTED DIRECTLY ACROSS THE GRID CIRCUIT OF THE AMPLIFIER'S INPUT TUBE AS SHOWN IN FIG.16. THE CHARACTERISTICS OF THE CRYSTAL PICK-UP ARE SUCH THAT THE FREQUENCY RESPONSE IS QUITE UNIFORM OVER A FREQUENCY RANGE EXTENDING FROM 30 TO 8000 CYCLES. THE AVERAGE VOLTAGE OUTPUT OF THE CRYSTAL PICK-UP FROM COMMERCIAL RECORDS IS AROUND 2 VOLTS. THE NEEDLES RECOMMENDED FOR THIS TYPE OF PICK-UP ARE THE REGULAR HALF-TONE OR TRANSCRIPTION NEEDLES.

WHEN THE LENGTH OF THE LINE BETWEEN THE CRYSTAL PICK-UP AND THE AMPLIFIER IS CONSIDERABLE, THEN AN IMPEDANCE MATCHING TRANSFORMER CAN BE USED IN THE MANNER AS ILLUSTRATED IN FIG.17. HERE THE PRIMARY WINDING OF THE COUPLING TRANSFORMER SHOULD HAVE AN IMPEDANCE RATING OF APPROXIMATELY 150,000 OHMS WHILE ITS SECONDARY SHOULD MATCH THE LOW IMPEDANCE OF THE LINE

FOR SOUND PICTURE WORK, AS WELL AS FOR ELECTRICAL TRANSCRIPTION REPRODUCTIONS, YOU WILL FREQUENTLY FIND NEEDLE SCRATCH FILTERS EMPLOYED IN THE SAME MANNER AS HAS ALREADY BEEN EXPLAINED IN A PREVIOUS LESSON TREATING WITH RADIO-PHONOGRAPH COMBINATIONS.

REPRODUCING SOUND FROM THE RECORDS

NOW WE ARE READY TO REPRODUCE THE SOUNDS FROM THE RECORD AND THE SET UP IS CLEARLY SHOWN IN FIG.18. VARIOUS ARRANGEMENTS ARE BEING US

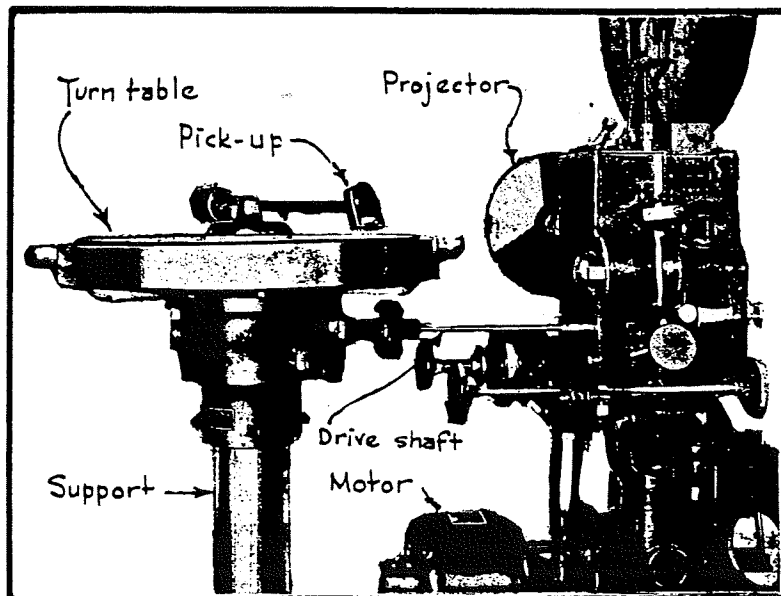


FIG. 18
A Turntable Attached to a Motion Picture Projector

ED BUT IN THE EXAMPLE HERE ILLUSTRATED, THE TURN TABLE IS MOUNTED ON A STAND ADJACENT TO THE PICTURE PROJECTOR, WHICH IS OF THE CONVENTIONAL TYPE, OR THE SAME AS THAT USED FOR THE REPRODUCTION OF SILENT PICTURES. THE ONLY MAJOR DIFFERENCE IS THAT THE DRIVING MECHANISM, WHICH REELS THE FILM THROUGH THE PROJECTOR, IS COUPLED TO THE TURN TABLE AS INDICATED IN FIG. 18, SO THAT BOTH UNITS WILL OPERATE IN PERFECT SYNCHRONISM WITH EACH OTHER.

THE PICK UP UNIT IS MOUNTED ON THE END OF A PIVOTED ARM AND AN ADJUSTABLE COUNTERWEIGHT IS PROVIDED AT THE OTHER EXTREMITY OF THE ARM, SO THAT THE NEEDLE PRESSURE UPON THE RECORD CAN BE ADJUSTED.

AS THE RECORD IS ROTATED, THE PICK-UP NEEDLE RIDES IN THE GROOVE, VIBRATING FROM SIDE TO SIDE IN ACCORDANCE WITH THE IRREGULARITIES OF THE GROOVE, AND WHICH YOU WILL RECALL CORRESPOND TO THE SOUND IMPRESSIONS. AUDIO FREQUENCY VOLTAGES OF LIKE FREQUENCY ARE THUS INDUCED INTO THE PICK-UP COILS OR GENERATED BY A CRYSTAL, WHICHEVER THE CASE MAY BE. THESE VOLTAGE CHANGES ARE THEN APPLIED ACROSS THE INPUT TERMINALS OF AN A.F. AMPLIFIER, WHERE THEY ARE AMPLIFIED IN THE USUAL WAY AND FINALLY REPRODUCED AS SOUND BY A LOUD SPEAKER OR SYSTEM OF SPEAKERS, THESE SOUNDS, OF COURSE WILL BE AN EXACT REPRODUCTION OF THOSE WHICH WERE ORIGINALLY RECORDED AT THE TIME THAT THE PICTURE WAS BEING PRODUCED.

OPERATING OF FILM PROJECTORS

AS YOU PROBABLY ALREADY KNOW, THE FILM FOR A COMPLETE PICTURE IS DIVIDED INTO REELS OR SEVERAL SPOOLS OF CONTINUOUS FILM. CONSEQUENTLY, IT IS NECESSARY TO CHANGE REELS DURING THE SHOWING OF THE PICTURE AND TO MAKE THIS POSSIBLE IN SUCH A WAY THAT THE CHANGE IN REELS IS NOT NOTICEABLE TO THE AUDIENCE, TWO SEPARATE PROJECTORS ARE HOUSED IN THE PROJECTION BOOTH. ONE OF THESE, WITH ITS ACCOMPANYING TURN TABLE FOR RECORD REPRODUCTION IN CONJUNCTION WITH FILM SOUND REPRODUCTION IS SHOWN IN FIG. 19.

ONE OF THE PROJECTORS IS THROWING THE PICTURES UPON THE SCREEN WITH THE ACCOMPANYING RECORDING AND DURING THIS TIME, THE FOLLOWING REEL IS THREADED INTO THE SECOND PROJECTOR, WHICH IS THOROUGHLY PREPARED TO BE

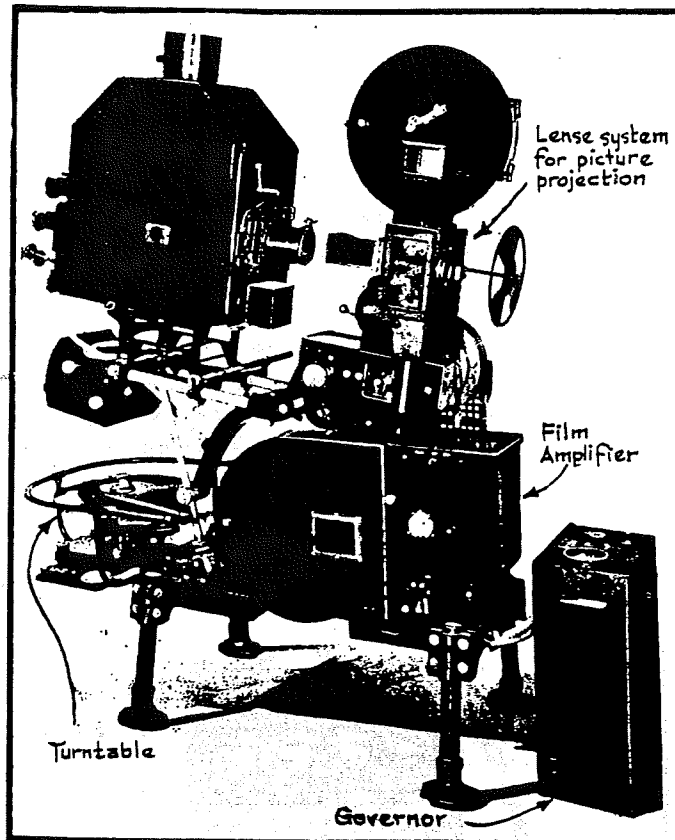


FIG. 19
*Simplex Projector With Western Electric
Sound Equipment.*

SET INTO IMMEDIATE OPERATION. THE SAME IS TRUE WITH RESPECT TO THE FOLLOWING RECORD. THEN AS THE FIRST PROJECTOR FINISHES SHOWING ITS REEL, THE SECOND PROJECTOR IS PUT INTO OPERATION, TAKING UP THE SHOWING WHERE THE FIRST LEFT OFF. THE END OF THE FIRST AND THE BEGINNING OF THE SECOND REEL ARE SO MADE AS TO OVERLAP AND THE PICTURE FROM THE FIRST REEL FADES INTO THAT OF THE SECOND REEL SO THAT THIS CHANGEOVER IS NOT NOTICEABLE TO THE AUDIENCE.

AS THE SECOND PROJECTOR TAKES OVER ITS DUTIES, THE FIRST PROJECTOR IS SHUT DOWN AND "THREADED" FOR THE THIRD REEL AND IT WILL CONTINUE WHERE THE SECOND LEAVES OFF ETC. THIS PROCESS IS CONTINUED UNTIL THE END OF THE PICTURE AND TO THE AUDIENCE, THE PICTURE APPEARS TO BE ONE CONTINUOUS FILM.

AT THE END OF A RECORD, THE MUSIC OR SPEECH COMING FROM ONE MACHINE MUST BE BLENDED UNOTICEABLY INTO THAT FROM THE OTHER, JUST AS THE PICTURE FROM ONE REEL IS FADED INTO THAT OF THE FOLLOWING ONE. TO ACCOMPLISH THIS, YOU WILL FIND THAT AT THE END OF EACH RECORDING DISC, THE MUSIC OR SPEECH OVERLAPS THAT AT THE BEGINNING OF THE NEXT AND A FADER MAKES THIS CHANGEOVER IN SOUND EFFECTS POSSIBLE WITHOUT BEING PERCEPTIBLE TO THE AUDIENCE.

AS THE STARTING PROJECTOR GOES INTO OPERATION, THE FADER KNOB IS TURNED AND THE ENERGY DELIVERED TO THE AMPLIFIERS IS CHANGED QUICKLY UNTIL IT COMES ENTIRELY FROM THE NEW RECORD. THE FADER ALSO SERVES AS A VOLUME CONTROL AND THUS PERMITS AN ADJUSTMENT WHEREBY IT MAKES IT POSSIBLE TO EQUALIZE THE LEVEL OF SOUND AS OBTAINED FROM THE DIFFERENT RECORDS. THE FADER OPERATES THE SAME AS SHOWN YOU IN YOUR AMPLIFIER SERIES.

THE PROBLEM OF SYNCHRONIZING THE RECORD TO THE PROJECTOR IS QUITE

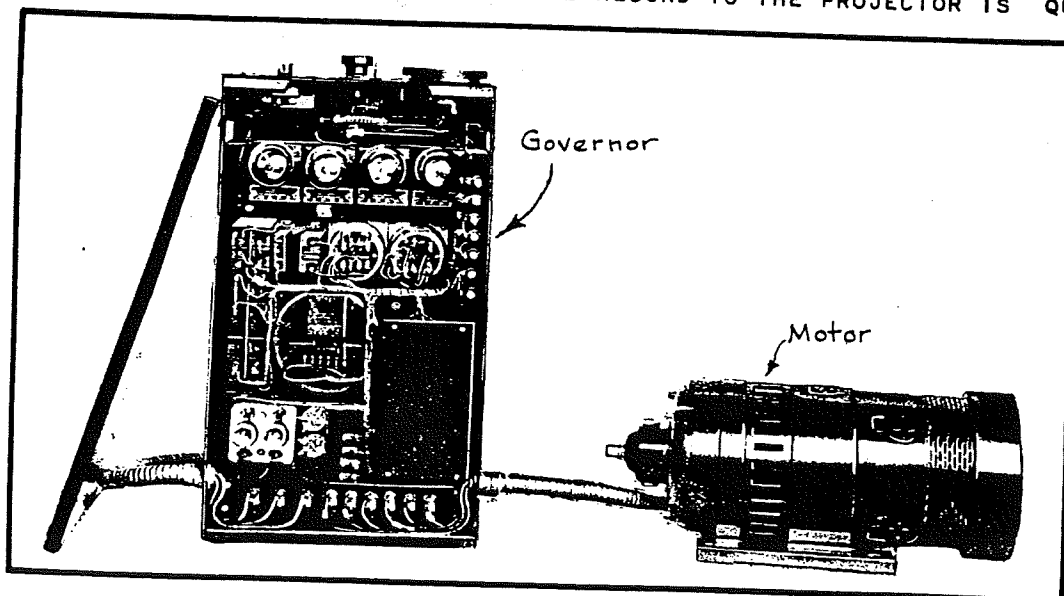


FIG. 20
An Alternating Current Drive Motor Connected
to the Electric Operated Governor.

EXAMINATION QUESTIONS

LESSON NO. SP-I

Not every piece produced by
a master is necessarily a masterpiece.

J. A. ROSENKRANZ

1. - WHAT IS A "RECORDER" AS USED IN THE MAKING OF DISC RECORDINGS FOR SOUND PICTURES?
2. - IN THE MAKING OF DISC RECORDINGS, IS IT THE GENERAL PRACTICE TO MODULATE THE RECORD GROOVE BY VARYING ITS DEPTH?
3. - IS IT POSSIBLE TO REPRODUCE THE SOUNDS DIRECTLY FROM THE "WAX" IMMEDIATELY AFTER IT HAS BEEN CUT?
4. - WHAT IS A "MASTER", AS USED IN THE MANUFACTURE OF RECORDS?
5. - BRIEFLY DESCRIBE THE FUNDAMENTAL OPERATING PRINCIPLES OF AN OIL-DAMPED PHONOGRAPH PICK-UP UNIT.
6. - HOW ARE THE TURN TABLE AND FILM PROJECTOR GENERALLY KEPT SYNCHRONIZED?
7. - OF WHAT USE IS THE "FADER" WHEN SHOWING SOUND PICTURES IN A THEATER?
8. - DOES THE PITCH OF RECORDED SOUND BECOME HIGHER OR LOWER AS THE SPEED OF THE TURNTABLE IS INCREASED?
9. - DESCRIBE THE STRUCTURAL FEATURES OF THE CRYSTAL-TYPE PHONOGRAPH PICK UP.
10. - DESCRIBE THE VARIOUS STEPS NECESSARY IN THE RECORDING OF SOUND ON DISC.