AN INTRODUCTION TO

Bally MIDWAY

FLIPPER GAMES

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INTRODUCTION

IT IS THE PURPOSE OF THIS OUTLINE TO SUMMARIZE THE ESSENTIAL COMPONENTS THAT MAKE UP A COIN-OPERATED FLIPPER GAME. IT IS WRITTEN, PRIMARILY, TO PROVIDE A FOUNDATION AND BACKGROUND FOR THE PEOPLE WHO SERVICE THESE GAMES.

NO ONE CAN HOPE TO MEMORIZE EVERY DETAIL OF EVERY CIRCUIT AND COMPONENT IN TODAY'S GREAT VARIETY OF GAMES. A GOOD TECHNICIAN DOES NOT EVEN ATTEMPT IT. INSTEAD, HE SHOULD BE ABLE TO OBTAIN INFORMATION AS HE NEEDS IT; FROM THE INSTRUCTION SHEETS, DRAWINGS AND SCHEMATICS PROVIDED WITH EACH PARTICULAR GAME.

TO DO THIS, HE MUST BE ABLE TO READ AND INTERPRET THE SCHEMATIC DIAGRAM.

THE ABILITY TO READ A DRAWING, COUPLED WITH THE BASIC PRINCIPLES OF ELECTRICITY, WILL MAKE IT EASIER TO UNDERSTAND, ADJUST, OPERATE AND REPAIR ANY GAME OR ELECTRICAL DEVICE.

UNDERSTANDING SCHEMATIC CIRCUITS

THE SCHEMATIC CIRCUIT IS A COMPLETE DRAWING OF ALL THE INDIVIDUAL ELECTRICAL CIRCUITS. A SHORTHAND SYSTEM OF SYMBOLS AND LINES IS USED. THE SYMBOLS REPRESENT SWITCHES, COILS, FUSES, TRANSISTORS, ETC. THE LINES INDICATE HOW THESE ARE CONNECTED TOGETHER.

A KNOWLEDGE OF THE MECHANICAL MOVEMENT OF THE COMPONENTS THAT ACTUATE THE VARIOUS SWITCHES IS NECESSARY.

NOT ALL THE SWITCHES OF A COMPONENT ASSEMBLY ARE TOGETHER ON THE SCHEMATIC DRAWING. THE SWITCHES OF AN ASSEMBLY ARE DIVORCED AND SHOWN INDIVIDUALLY ONLY IN THAT CIRCUIT IN WHICH IT IS USED.

AT FIRST GLANCE, THE SCHEMATIC MAY LOOK COMPLICATED. ACTUALLY, IT IS NOTHING MORE THAN A COLLECTION OF MANY SIMPLE CIRCUITS, EACH DESIGNED TO DO A PARTICULAR JOB.

IN TROUBLE SHOOTING, IT IS IMPORTANT TO ISOLATE THE PROBLEM. REFERENCE TO THE SCHEMATIC IS THEN MADE ONLY TO THOSE CIRCUITS THAT APPLY.

THE ELECTRONIC GAMES INCLUDE A SERIES OF SCHEMATICS WHICH ARE ON INDIVIDUAL SECTIONS OF THE GAMES.

TERMS AND DEFINITIONS

ACTUATOR

THAT PORTION OF A DEVICE THAT OPERATES A SWITCH.

ADJUSTMENT

THE SPACING OF CONTACTS ON SWITCH BLADES IN A SWITCH ASSEMBLY. THE PLACEMENT OF CERTAIN LEVERS, PAWL, STOP BRACKETS, POSTS, ETC.

ALTERNATING CURRENT

ELECTRICAL CURRENT, THE FLOW OF WHICH ALTERNATES AT REGULAR INTERVALS.

AMPLITUDE MODULATION

VARIETY OF ANALOG WHEREBY INFORMATION IS SENT THROUGH THE CIRCUIT BY MODULATING THE AMPLITUDE OR HEIGHT OF ELECTRICAL WAVES.

ANALOG

METHOD OF SENDING INFORMATION THROUGH AN ELECTRICAL CIRCUIT BY REGULATING CURRENT OR VOLTAGE.

ANODE (TERMINAL)

THE SEMI-CONDUCTOR DIODE TERMINAL THAT IS POSITIVE WITH RESPECT TO THE OTHER TERMINAL WHEN THE DIODE IS BIASED IN THE FORWARD POSITION.

ARC

THE DISCHARGE OF ELECTRICAL ENERGY THROUGH A GAS, SUCH AS AIR.

ARMATURE

A MOVEABLE PIECE OF METAL ATTRACTED BY A MAGNETIC FIELD.

BACK-UP BLADE

AN AUXILIARY BLADE TO DAMPEN THE VIBRATION OF ITS ADJOINING OPERATING BLADE.

TERMS AND DEFINITIONS (CONTINUED)

BALL EJECT SOLENOID

THE SOLENOID TO OPERATE MECHANISM TO KICK BALL OUT OF A HOLE OR POCKET.

BALL SHOOTER

THE SPRING LOADED ROD, OPERATED BY THE PLAYER, TO PROPEL THE BALL INTO THE PLAYFIELD AREA.

BANK

A NUMBER OF RELAYS MOUNTED INTO A COMMON ASSEMBLY.

BASE

THE REGION BETWEEN THE EMITTER AND THE COLLECTOR OF A TRANSISTOR WHICH RECEIVES MINORITY CARRIERS INJECTED FROM THE EMITTER.

BLADE

A HIGHLY CONDUCTIVE, SPRING-TYPE METAL, IN THE USE OF A SWITCH.

BONUS SCORE

AN ACCUMULATED SCORE ADDED TO THE TOTAL SCORE, WHEN A CERTAIN FEAT IS ACCOMPLISHED.

BRIDGE RECTIFIER

A FULL-WAVE RECTIFIER WITH FOUR ELEMENTS CONNECTED IN THE FORM OF A BRIDGE CIRCUIT SO THAT D.C. VOLTAGE IS OBTAINED FROM ONE PAIR OF OPPOSITE JUNCTIONS WHEN AN ALTERNATING VOLTAGE IS APPLIED TO THE OTHER PAIR OF JUNCTIONS.

BUFFER

AN ISOLATING CIRCUIT USED IN AN ELECTRONIC COMPUTER TO AVOID REACTION OF A DRIVEN CIRCUIT ON THE CORRESPONDING DRIVER CIRCUIT.

BUFFER AMPLIFIER

AN AMPLIFIER DESIGNED TO ISOLATE A PRECEDING

TERMS AND DEFINITIONS (CONTINUED)

BUFFER AMPLIFIER (CONTINUED)

CIRCUIT FROM THE EFFECTS OF A FOLLOWING CIRCUIT.

CAM

A METAL, PLASTIC OR BAKELITE DISC WITH NOTCHED DWELLS OR LOBES, ATTACHED TO A MOTOR SHAFT OR EXTENSION OF A MOTOR SHAFT. THE DISC OPERATES ASSOCIATED SWITCHES WHEN MOTOR IS OPERATING.

CAPACITANCE

ONE CAUSE OF REACTANCE. THE CHARACTERISTIC THAT TENDS TO IMPEDE CHANGES IN VOLTAGE BY THE CAPACITY OF THAT DEVICE OR CONDUCTOR TO STORE AND RELEASE ELECTRONS.

CAPACITOR

A DEVICE CONSISTING ESSENTIALLY OF TWO CONDUCTING SURFACES, SEPARATED BY AN INSULATING MATERIAL OR DIELECTRIC SUCH AS AIR, PAPER, MICA, GLASS, PLASTIC FILM OR OIL.

A CAPACITOR STORES ELECTRICAL ENERGY, BLOCKS THE FLOW OF ALTERNATING CURRENT TO A DEGREE DEPENDENT ESSENTIALLY UPON THE CAPACITANCE AND THE FREQUENCY.

CATHODE

WHEN A SEMI-CONDUCTOR DIODE IS BIASED IN THE FORWARD DIRECTION, THAT TERMINAL OF THE DIODE IS NEGATIVE WITH RESPECT TO THE OTHER TERMINAL.

CIRCUIT

A CLOSED NETWORK OF CONDUCTORS THRU WHICH AN ELECTRIC CURRENT CAN FLOW.

COIL

MANY TURNS OF INSULATED WIRE WOUND ON A SPOOL. USED TO CREATE A MAGNETIC FIELD WHEN ENERGIZED.

TERMS AND DEFINITIONS (CONTINUED)

COIL STOP OR CORE PLUG

A SMALL ASSEMBLY AT THE BOTTOM OF A SOLENOID WHICH IS USED AS A STOP FOR THE PLUNGER.

COIN CHUTE

MECHANISM THAT TESTS COIN FOR SIZE, WEIGHT AND MATERIAL BEFORE PASSING THRU TO ACTUATE COIN SWITCH.

COIN LOCKOUT COIL

A DEVICE MOUNTED ON THE COIN CHUTE ASSEMBLY THAT ALLOWS COINS TO DROP TO THE COIN CHUTE SWITCHES WHEN THE COIL IS ENERGIZED. WHEN NOT ENERGIZED, THE COINS ARE REJECTED AND RETURNED TO THE PLAYER.

COLLECTOR

THE COLLECTOR OF A TRANSISTOR IS AN ELECTRODE THROUGH WHICH A PRIMARY FLOW OF CARRIERS LEAVES THE INTER-ELECTRODE REGION.

CORE

THE STATIONARY SOFT IRON IN THE CENTER OF A COIL WINDING -- AS IN A RELAY OR TRANSFORMER.

CURRENT

THE FLOW OF ELECTRONS CAUSED BY AN ELECTRICAL FORCE CALLED VOLTAGE. THE AMOUNT THAT WILL FLOW FOR A GIVEN VOLTAGE IS DEPENDENT ON THE ELECTRICAL IMPEDENCE OF THE CIRCUIT. THE UNIT OF MEASUREMENT OF CURRENT IS AMPERE.

DIGITAL

METHOD OF SENDING INFORMATION THROUGH AN ELECTRICAL CIRCUIT BY SWITCHING THE CURRENT ON OR OFF.

DIGITAL DISPLAY

PANEL CONSISTING OF SIX (6) DIGITS, EACH HAVING SEVEN (7) SEGMENTS USED FOR SHOWING SCORE, CREDITS AND BALL IN PLAY INFORMATION TO THE PLAYER.

TERMS AND DEFINITIONS (CONTINUED)

DIODE

AN ELECTRON TUBE HAVING TWO (2) ELECTRODES, A CATHODE AND AN ANODE.

DIP SWITCH

STANDARD ON/OFF OR OPEN/CLOSED TYPE SWITCH; USED ON THE MPU MODULE TO CONTROL CERTAIN GAME FUNCTIONS.

DIRECT CURRENT

FLOW OF ELECTRONS WHICH ONLY GOES IN ONE DIRECTION.

DISC

THE STATIONARY BAKELITE PIECE TO WHICH RIVETS OR ETCHED COPPER LAMINATE IS ATTACHED. USED ON STEP-UP UNITS, DRUM UNITS, MOTOR UNITS, ETC.

DRIVE ARM

THE STEP-UP LEVER THAT IS OPERATED BY THE SOLENOID PLUNGER TO ADVANCE THE RATCHET GEAR.

DRIVE PAWL

ATTACHED TO THE DRIVE ARM, IT ENGAGES THE NEXT TOOTH OF THE RATCHET GEAR TO ADVANCE WHEN SOLENOID IS DE-ENERGIZED. ADVANCING THE RATCHET IS DONE BY SPRING CONNECTED TO THE DRIVE ARM AND DRIVE PAWL.

ESCAPEMENT PAWL

USED TO SINGLE STEP RESET TYPE UNIT, IT ALLOWS THE RATCHET TO RETURN ONLY ONE POSITION WHEN THE RESET PAWL IS DISENGAGED.

ELECTRONS

TINY PARTICLES MAKING UP ELECTRICITY.

EMITTER

AN ELECTRODE WITHIN A TRANSISTOR FROM WHICH CARRIERS ARE USUALLY MINORITY CARRIERS; WHEN THEY ARE MAJORITY CARRIERS, THE EMITTER IS REFERRED TO AS A MAJORITY EMITTER.

TERMS AND DEFINITIONS (CONTINUED)

FLIP FLOP

A DIGITAL BUILDING BLOCK THAT, UPON COMMAND FROM A CLOCK PULSE RECEIVED AT ONE INPUT, STORES AT ITS OUTPUT, A BIT OF INFORMATION RECEIVED AT ANOTHER INPUT.

FLIPPER

ELECTRICALLY OPERATED, BAT-TYPE LEVER, CONTROLLED BY PLAYER TO MANIPULATE THE BALL ON THE PLAYFIELD.

FREQUENCY MODULATION

VARIETY OF ANALOG WHEREBY INFORMATION IS SENT THROUGH THE CIRCUIT BY MODULATING THE FREQUENCY OF THE ELECTRICAL WAVES.

GAP

AIR SPACE BETWEEN A SET OF CONTACT POINTS.

GATE

THE CONTROL TERMINAL AND CONTROLLING REGION OF A FIELD-EFFECT TRANSISTOR. CORRESPONDS TO BASE OF BI-POLAR TRANSISTOR.

GATE (PLAYFIELD)

A ONE-WAY DEVICE THAT ALLOWS THE BALL TO ENTER THE PLAYFIELD OR AN ALLEY ON THE PLAYFIELD, AND ACTS AS A REBOUND IN THE OPPOSITE DIRECTION.

ALSO, AN ELECTRICALLY OPERATED DEVICE THAT WILL ALLOW THE BALL TO ENTER BALL SHOOTER ALLEY AND BE SHOT AGAIN WITHOUT BEING COUNTED.

HEAT SINK

A MOUNTING BASE, USUALLY METALLIC, THAT DISSIPATED, CARRIES AWAY, OR RADIATES INTO THE SURROUNDING ATMOSPHERE, THE HEAT GENERATED WITHIN A SEMI-CONDUCTOR DEVICE.

TERMS AND DEFINITIONS (CONTINUED)

HOLD OVER

GENERALLY A FEATURE OF THE GAME THAT IS NOT RESET AT THE BEGINNING OF A NEW GAME; RATHER, IT IS CARRIED ON UNTIL THE FEATURE AWARD IS EARNED.

HOLD OVER MAY ALSO APPLY TO A FEATURE OF THE GAME THAT RESETS AT THE START OF A GAME, BUT IS CARRIED OVER FROM BALL TO BALL DURING A GAME.

IT MAY BE A HOLD OVER UNTIL THE START OF A GAME OR IT MAY BE A HOLD OVER UNTIL THE FEATURE AWARD IS EARNED.

IT MAY BE CARRIED OVER MORE THAN ONE PLAY ON THE MACHINE.

INSERT

THE PANEL MOUNTED IN THE BACK BOX ON WHICH DRUM UNITS, LITES, RELAYS AND OTHER UNITS ARE MOUNTED.

INSULATOR

A MATERIAL THAT DOES NOT CONDUCT ELECTRICAL CURRENT.

INTEGRATED CIRCUIT

ABBREVIATED I.C. ANY ELECTRICAL DEVICE IN WHICH BOTH ACTIVE AND PASSIVE ELEMENTS ARE CONTAINED IN A SINGLE PACKAGE CONTAINING TRANSISTORS AND, PERHAPS, DIODES; RESISTORS AND CAPACITORS; ALONG WITH INTERCONNECTING ELECTRICAL CONDUCTORS, PROCESSED AND CONTAINED ENTIRELY WITHIN A SINGLE CHIP OF SILICON.

INTERLOCK RELAY

A RELAY CONSISTING OF TWO COILS WHOSE ARMATURES ARE MUTUALLY LOCKED IN MECHANICALLY.

LATCH

A MECHANICALLY LOCKING DEVICE.

TERMS AND DEFINITIONS (CONTINUED)

LIGHT EMITTING DIODE

ABBREVIATED LED A PN JUNCTION THAT EMITS LIGHT WHEN BIASED IN THE FORWARD POSITION.

LITE BOX

THE WOODEN BOX MOUNTED ON THE REAR OF THE CABINET. SOMETIMES REFERRED TO AS A BACK-BOX.

LINK

CONNECTING PIECE BETWEEN TWO MOVING PARTS.

LOCK ARM

A MECHANICAL LATCH DEVICE ON A STEP-UP UNIT TO INSURE FULL RETURN (INDEX) OF THE RATCHET UPON RESET. SOMETIMES CALLED A CATCH PAWL OR A RESET LATCH.

LOCK IN

A TERM APPLIED WHEN A RELAY IS KEPT ENERGIZED THRU A SWITCH OF ITS OWN, AFTER THE ORIGINAL SOURCE OF ENERGY HAS BEEN REMOVED.

LOGIC GATES

SWITCHING CIRCUIT BUILDING BLOCKS WHICH UTILIZE YES AND NO STATEMENTS AS INPUTS TO MAKE CERTAIN, SIMPLE DECISIONS, WITH THE ANSWER ALSO EXPRESSED AS YES AND NO.

MAGNET COIL

A COIL WOUND AROUND A STATIONARY SOFT IRON CORE, SUCH AS A RELAY COIL.

MODULE

AN INDIVIDUAL PRINTED CIRCUIT BOARD.

MOUNTING PANEL

THE BOARD LOCATED ON THE FLOOR, INSIDE CABINET, USED TO MOUNT TRANSFORMER, SCORE MOTOR UNIT, RELAYS, ETC.

TERMS AND DEFINITIONS (CONTINUED)

MOS

METAL-OXIDE-SEMI-CONDUCTOR, REFERRING TO A FIELD EFFECT TRANSISTOR THAT HAS A METAL GATE INSULATED BY AN OXIDE LAYER FROM THE SEMI-CONDUCTOR CHANNEL.

MULTIPLEXER

A DECISION MAKING TYPE OF DIGITAL BUILDING BLOCK THAT ROUTES DATA FROM ITS ONE INPUT TO ANY ONE OF SEVERAL OUTPUTS.

OUT HOLE

REFERS TO HOLE OR CUP AT BOTTOM SECTION OF PLAY-FIELD, LOCATED UNDER BOTTOM ARCH. DURING PLAY OF GAME, THE BALL IS KICKED OUT OF OUT HOLE KICKER, OVER THE BALL TROUGH, TO SHOOTER OR ALLEY.

P.I.A.

PEREPHERAL INTERFACE ADAPTOES; I.C.S THAT ACT AS INPUT AND OUTPUT UNITS (INTERFACES) FOR INFORMATION IN DIGITAL SYSTEMS. THE GENERAL FUNCTION IS BASICALLY A MATTER OF AMPLIFYING DIGITAL SIGNALS.

PLAYFIELD

PLAY AREA OF A GAME.

PLUMB TILT

PENDULUM TYPE TILT SWITCH, GENERALLY LOCATED ON CABINET TO LEFT OF COIN BOX.

PLUNGER

A SOFT IRON ROD THAT IS ATTACHED TO THE SOLENOID'S MAGNETIC FIELD. THIS MOVEMENT IS LINKED TO DO MECHANICAL WORK.

RAM

RANDOM ACCESS MEMORY; A CERTAIN KIND OF MEMORY-TYPE BUILDING BLOCK, COMMONLY AVAILABLE IN MOS IC FORM, USUALLY CONSISTING OF A NUMBER OF FLIP-FLOPS. BITS OF BINARY INFORMATION CAN BE WRITTEN INTO OR READ OUT OF ANY OF THE FLIP-FLOPS AT WILL.

TERMS AND DEFINITIONS (CONTINUED)

RATCHET

A CIRCULAR, NOTCHED (GEARED) PIECE OF METAL OR PLASTIC, USED TO ROTATE STEP-UP UNIT.

REJECTOR

SEE COIN CHUTE

RELAY

AN ELECTRICALLY OPERATED COMPONENT THAT CAN CONTROL TWO OR MORE CIRCUITS FROM THE COMPLETION OF ONE CIRCUIT.

REPLAY BUTTON

MOUNTED AT THE FRONT OF THE GAME AND USED BY THE PLAYER TO START A NEW GAME, WITHOUT THE USE OF A COIN.

RESET PAWL

HOLDS THE RATCHET IN POSITION BETWEEN STEP-UPS SO THAT THE WIPER ASSEMBLY IS CENTERED ON RIVETS.

ALSO PREVENTS THE RATCHET FROM RESETTING BETWEEN STEP-UPS ON A RESET TYPE UNIT.

SOMETIMES REFERRED TO AS AN INDEX PAWL.

RESIDUAL

THE UNWANTED LEFTOVER MAGNETISM LEFT IN THE ARMATURE AFTER THE ELECTRICAL ENERGY HAS BEEN REMOVED.

RESISTANCE

PROPERTY OF MATTER THAT RESTRICTS OR IMPEDES THE FLOW OF ELECTRICAL CURRENT. MEASURED IN UNITS CALLED OHMS.

RESISTOR

A DEVICE CONNECTED INTO AN ELECTRICAL CIRCUIT TO INTRODUCE A SPECIFIED RESISTANCE.

TERMS AND DEFINITIONS (CONTINUED)

ROM

READ ONLY MEMORY; IS A TYPE OF BUILDING BLOCK CLASSIFIED AS A MEMORY TYPE. INFORMATION IS STORED IN A PERMANENT FORM BY DESIGN, CHIEFLY, OF THE INTERCONNECTION. INFORMATION CAN BE READ OUT ONLY.

SCHEMATIC

DRAWING SHOWING COMPLETE WIRING OF ALL COMPONENTS BY MEANS OF A SHORTHAND SYSTEM OF SYMBOLS AND LINES.

SCR

SILICON CONTROLLED RECTIFIER. FORMAL NAME IS 'REVERSE BLOCKING TRIODE THYRISTOR' - A THYRISTOR THAT CAN BE TRIGGERED INTO CONDUCTION IN ONLY ONE DIRECTION. IT CONSISTS OF THREE TERMINALS: CATHODE, ANODE AND GATE.

SEQUENCE

A DEFINITE PRE-DETERMINED PATTERN OR ORDER OF OPERATION.

SHOOTER

SPRING LOADED ROD OPERATED BY PLAYER TO PROPEL BALL FROM SHOOTER ALLEY ONTO PLAYFIELD.

SHIFT REGISTER

A DIGITAL BUILDING BLOCK CONSISTING OF ANY NUMBER OF FLIP-FLOPS CONNECTED IN SERIES WITH A COMMON CLOCK SIGNAL, SO THAT UPON EACH CLOCK PULSE, EACH BIT OF INFORMATION BEING STORED SHIFTS TO THE NEXT FLIP-FLOP IN THE CHAIN.

SLAM TILT

SWITCH ASSEMBLY WITH AN ATTACHED WEIGHT TO THE END OF THE LONG BLADE, SO THAT SWITCH WILL 'MAKE' WHEN GAME IS JARRED OR BOUNCED.

TERMS AND DEFINITIONS (CONTINUED)

SLEEVE

A REPLACEABLE LINER INSIDE A SOLENOID.

SLO-BLO FUSE

A DELAYED ACTION FUSE. CAN WITHSTAND A MOMENTARY SURGE OF HIGH CURRENT, BUT WILL OPEN UP IF THE EXCESS CURRENT IS SUSTAINED.

SOLENOID

A COIL OF INSULATED WIRE WITH A HOLLOW CORE INTO WHICH A PLUNGER IS PULLED WHEN COIL IS ENERGIZED.

STEP-UP UNIT

AN ELECTRICALLY DRIVEN ROTARY TYPE OF SWITCH.

SWITCH SPACERS

SMALL BAKELITE PIECES SEPARATING ONE SWITCH BLADE FROM ANOTHER.

TIMER

A SPECIAL CLOCK MECHANISM OR MOTOR-OPERATED DEVICE USED TO PERFORM SWITCHING OPERATIONS AT PREDETERMINED TIME INTERVALS.

THUMPER BUMPER

BUMPER THAT AUTOMATICALLY KICKS THE BALL WHEN CALL HITS BUMPER SKIRT.

TORSION SPRING

SPRING AROUND A SHAFT THAT WINDS UP AS THE SHAFT IS ROTATED.

TRANSFORMER

AN ELECTRICAL COMPONENT CONSISTING OF TWO OR MORE COUPLED WINDINGS, WITH OR WITHOUT A MAGNETIC CORE, FOR INDUCING MUTUAL COUPLING BETWEEN CIRCUITS.

PRIMARILY USED TO CHANGE VOLTAGE RATIOS, UP OR DOWN.

TERMS AND DEFINITIONS (CONTINUED)

TRANSISTOR

AN ACTIVE SEMI-CONDUCTOR DEVICE, USUALLY MADE OF SILICON OR GERMANIUM, HAVING THREE OR MORE ELECTRODES. THE THREE MAIN ELECTRODES USED ARE THE EMITTER, BASE AND COLLECTOR.

CONDUCTION IS BY MEANS OF ELECTRONS (ELEMENTARY PARTICLES HAVING THE SMALLEST NEGATIVE ELECTRICAL CHARGE THAT CAN EXIST), AND HOLES (MOBILE ELECTRON VACANCIES EQUIVALENT TO A POSITIVE CHARGE).

VARISTOR

A TWO-ELECTRODE SEMI-CONDUCTOR DEVICE WITH A VOLTAGE-DEPENDENT NON-LINEAR RESISTANCE THAT DROPS MARKEDLY AS THE APPLIED VOLTAGE IS INCREASED.

VOLTAGE

ELECTRON PRESSURE OR DENSITY IN AN ELECTRICAL WIRE OR CIRCUIT.

VOLTAGE REGULATOR

A CIRCUIT THAT HOLDS AN OUTPUT VOLTAGE AT A PREDETERMINED VALUE OR CAUSES IT TO VARY ACCORDING TO A PREDETERMINED PLAN, REGARDLESS OF NORMAL INPUT-VOLTAGE CHANGES OR CHANGES IN THE LOAD IMPEDENCE.

WIPER ASSEMBLY

THE ROTATING CONTACT BLADES THAT COMPLETE THE CIRCUIT OF A STEP-UP UNIT DISC ASSEMBLY.

ZENER DIODE

A TWO LAYER DEVICE THAT, ABOVE A CERTAIN REVERSE VOLTAGE, HAS A SUDDEN RISE IN CURRENT. IF FORWARD BIASED, THE DIODE IS AN ORDINARY RECTIFIER. BUT, WHEN REVERSE BIASED, THE DIODE EXHIBITS A TYPICAL KNEE OR SHARP BREAK IN ITS CURRENT-VOLTAGE GRAPH.

TERMS AND DEFINITIONS (CONCLUDED)

ZENER DIODE (CONCLUDED)

THE VOLTAGE ACROSS THE DEVICE REMAINS ESSENTIALLY CONSTANT FOR ANY FURTHER INCREASE OR REVERSE CURRENT, UP TO THE ALLOWABLE DISSAPATION RATING.

THE ZENER DIODE IS A GOOD VOLTAGE REGULATOR, OVER VOLTAGE PROTECTOR, VOLTAGE REFERENCE, LEVEL SHIFTER, ETC.

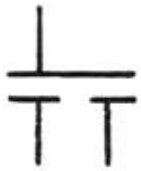
TRUE ZENER BREAKDOWN OCCURS AT LESS THAN SUX (6) VOLTS.

S Y M B O L S

NORMALLY OPEN, CLOSED WHEN ENERGIZED, MAKE OR TYPE A SW.

NORMALLY CLOSED, OPEN WHEN ENERGIZED, BREAK OR TYPE B SW.

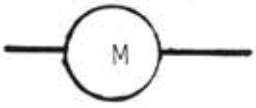
TRANSFER, MAKE-BREAK OR TYPE C SW.



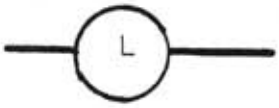
DOUBLE MAKE, MAKE-MAKE OR TYPE D SW.

SCORE MOTOR OPERATED SWITCH.

FUSE



MOTOR



LITE

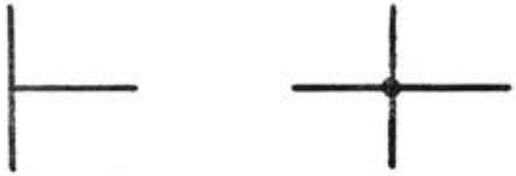
LINE PLUG

CHASSIS GROUND

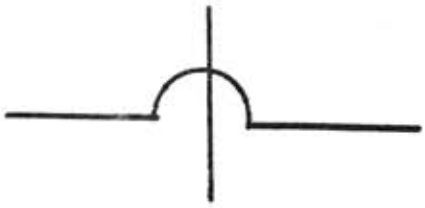
EARTH GROUNDING CONNECTION

COIL (RELAY COIL OR SOLENOID)

TRANSFORMER

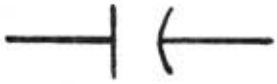


WIRES CONNECTED



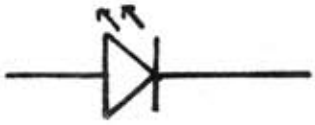
WIRES NOT CONNECTED

RESISTOR

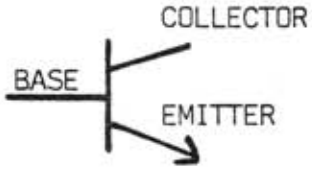


CAPACITOR OR CONDENSER

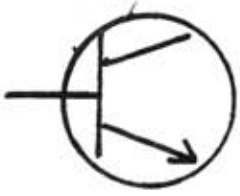
DIODE OR RECTIFIER



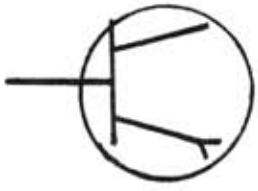
LED LIGHT-EMITTING DIODE



TRANSISTOR



NPN TRANSISTOR

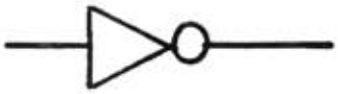


PNP TRANSISTOR

SCR SILICON CONTROLLED RECTIFIER

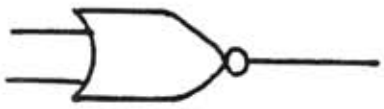
AND GATE THE OUTPUT IS YES (1) ONLY IF ALL INPUTS ARE YES

OR GATE THE OUTPUT IS YES (1) IF AT LEAST ONE INPUT IS YES



NOT GATE THE OUTPUT IS JUST THE OPPOSITE FROM THE SINGLE INPUT

NAND GATE (NOT-AND) GATE IS AN AND GATE FOLLOWED BE AN INVERTER. THE OUTPUT OF THE AND GATE IS INVERTED TO THE OPPOSITE VALUE.



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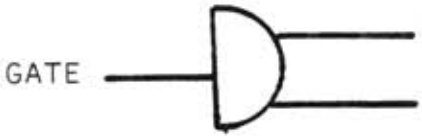
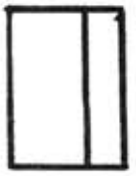
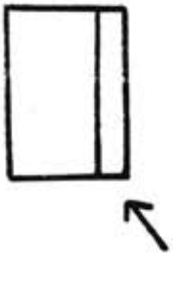


SILICON-CONTROLLED RECTIFIER
LEAD CONNECTIONS
LAMP DRIVER MODULE



MPU
MODULE
DISPLAY
DRIVER



BASE
COLLECTOR
EMITTER

SOLENOID
DRIVER

TRANSISTOR LEAD CONNECTIONS

BALLY WIRE COLOR CODE

1.	RED	(-R-)
2.	BLUE	(-BLU-)
3.	YELLOW	(-Y-)
4.	GREEN	(-G-)
5.	WHITE	(-W-)
6.	BROWN	(-BR-)
7.	ORANGE	(-O-)
8.	BLACK	(-B-)
9.	GRAY	(GRAY)

DASH BEFORE ABBREVIATION USED ONLY WHEN THERE IS NO TRACER

0. NO TRACER
J. JUMPER

FIRST NUMBER	=	WIRE BODY COLOR
SECOND NUMBER	=	TRACER COLOR
THIRD NUMBER (AFTER DASH)	=	RE-USE OF SAME COLOR WIRE

EXAMPLE:

50	=	WHITE WIRE WITH NO TRACER
51	=	WHITE WIRE WITH RED TRACER
51-1	=	WHITE WIRE WITH RED TRACER USED 2ND TIME
51-2	=	WHITE WIRE WITH RED TRACER USED 3RD TIME

K I T S

NUMBER	NAME	PURPOSE
485	AID UNITS	FOR TESTING WITH AS2518-17 MPU MODULE
485-1	AID UNITS	FOR TESTING WITH AS2518-17 AND AS2518-35 MPU MODULE
490	COMPONENTS	RECOMMENDED STOCK COMPONENTS FOR POWER TRANSFORMER MODULE
492	COMPONENTS	RECOMMENDED STOCK COMPONENTS FOR SOLENOID DRIVER/VOLTAGE REGULATOR MODULE
493	COMPONENTS	RECOMMENDED STOCK COMPONENTS FOR DISPLAY DRIVER MODULE
494	COMPONENTS	RECOMMENDED STOCK COMPONENTS FOR LAMP DRIVER MODULE
495	- - -	NEW KICKER ARM ASSEMBLY
503	COMPONENTS	RECOMMENDED STOCK COMPONENTS (LESS MEMORY) FOR MPU MODULE
507-1	TRANSFORMER KIT	FOR JAPAN ONLY (LOW VOLTAGE)
509	MOUNTING KIT	TRANSFORMER MOUNTING BRACKET KIT FOR ELECTRONIC GAMES
518	COMPONENTS	RECOMMENDED STOCK COMPONENTS FOR SOUND MODULE (LESS MEMORY)
523	MODIFICATION KIT	AS2518-17 MODIFICATION KIT
525	CONVERSION KIT	CONVERSION TO ELECTRONIC CHIME MODIFICATION
526	PARTS KIT	PARTS KIT FOR ELECTRONIC NOVELTIES, AUTOMATIC BALL SHOOTER
529	COIN COUNTER	MECHANICAL COIN COUNTER FOR ELECTRONIC GAMES

TROUBLE SHOOTING

NEVER EXPERIMENT WITH ANY OF THE MECHANISMS !

IMPROPER ADJUSTMENT, OR MAKESHIFT REPAIR, WILL ONLY CAUSE SERIOUS DAMAGE TO OTHER PARTS OF THE MACHINE, OR REPEATED FAILURE OF THE PART.

TO SERVICE ANY COIN-OPERATED AMUSEMENT GAME IN A MINIMUM OF TIME, IT IS NECESSARY TO ISOLATE THE PROBLEM TO A PARTICULAR CIRCUIT. A SYSTEM OF LOGICAL ELIMINATION WILL REDUCE THE POSSIBLE TROUBLE SPOTS.

THIS IS DONE -- IN AN ELECTRO-MECHANICAL GAME -- BY ATTEMPTING TO PLAY THE GAME AND OBSERVING THE RESULTS. WITH A LITTLE REASONING, A BRIEF REFERENCE TO THE SCHEMATIC AND, PERHAPS, A CONTINUITY CHECK, WILL INEVITABLY DETERMINE THE CAUSE.

THIS HAS BEEN MADE EASIER ON THE ELECTRONIC GAMES BY BUILT-IN TESTING FUNCTIONS THAT DEAL WITH ONE AREA AT A TIME TO DEFINE A PROBLEM.

A VISUAL INSPECTION OF THE COMPONENTS IN THE POSSIBLE TROUBLE AREA MAY OFTEN SAVE TIME.

ALWAYS LOOK FOR A POSSIBLE LOOSE WIRE, BAD CONNECTION AT A PLUG OR SOCKET, AND BROKEN OR UNHOOKED SPRINGS ON STEP-UPS, RELAYS, ETC.

SAFETY

CERTAIN SAFETY REQUIREMENTS SHOULD BE KEPT IN MIND WHEN A COIN-OPERATED MACHINE IS BEING SERVICED.

IT IS IMPORTANT TO REMEMBER THAT CURRENT IS THE ELECTRICAL SHOCK FACTOR RATHER THAN THE AMOUNT OF VOLTAGE. CURRENT FLOW IS EQUAL TO THE VOLTAGE DIVIDED BY THE RESISTANCE. WHEN THE SKIN IS WET OR MOIST, THE CONTACT RESISTANCE MAY DROP TO AS LOW AS 300 OHMS. WITH THIS LOW BODY RESISTANCE, EVEN A RELATIVELY LOW VOLTAGE CAN SUPPLY ENOUGH CURRENT TO BE FATAL.

DO NOT WORK ON ANY ELECTRICAL EQUIPMENT WITH WET HANDS OR WHILE WEARING WET CLOTHING OR SHOES. SHOES WITH WELL INSULATED SOLES AND HEELS SHOULD BE WORN.

CLEANING SOLVENTS, WHEN USED, REQUIRE CERTAIN SAFETY PRECAUTIONS ALSO.

VOLATILE LIQUIDS, SUCH AS BENZOL, TURPENTINE AND KEROSENE, CAN BE DANGEROUS BECAUSE OF THE POSSIBLE IGNITING OF FUMES BY A SPARK. IF THESE LIQUIDS ARE TO BE USED, BE SURE THE GAME IS TURNED OFF, AND THAT THERE IS SUFFICIENT VENTILATION TO AVOID AN ACCUMULATION OF FUMES, AND THAT ALL FUMES ARE CLEARED BEFORE THE GAME IS TURNED ON.

CARBON TETRACHLORIDE, ALTHOUGH IT DOES NOT CREATE A FIRE HAZARD, IT DANGEROUS BECAUSE OF THE ILL EFFECTS CAUSED BY BREATHING ITS VAPORS. IT MAY RESULT IN HEADACHE, NAUSEA OR DIZZINESS. IN A POORLY VENTILATED SPACE, IT CAN CAUSE UNCONCIOUSNESS OR EVEN DEATH.

AVAILABLE AT MANY LOCAL ELECTRICAL OR RADIO SUPPLY HOUSES ARE MANY COMMERCIAL SOLVENTS FOR ELECTRICAL AND MECHANICAL EQUIPMENT. THESE LEAVE NO RESIDUAL DEPOSITS, ARE NON-INFLAMMABLE AND COME IN CONVENIENT SPRAY CANS.

LUBRICATION

OVER-LUBRICATION CAUSES FAR MORE TROUBLE IN COIN-OPERATED EQUIPMENT THAN UNDER-LUBRICATION. PRACTICALLY ALL CASES OF POOR CONTACT ON SWITCHES AND WIPER DISCS ARE DUE TO OIL OR GREASE, OR OIL VAPOR, WHICH FORMS A FILM OR RESIDUE ON THE CONTACTS AND WILL NOT ALLOW CURRENT TO PASS THROUGH. EXCESS LUBRICANT MAY ALSO SEEP INTO THE CLUTCHES, CAUSING THEM TO SLIP.

IMPORTANT: NEVER USE VASELINE FOR LUBRICATION OF ANY PART OF THE MACHINE!

VASELINE IS NOT A TRUE LUBRICANT. IT LEAVES A DIRTY AND GUMMY RESIDUE AND IT BECOMES VERY THICK WHEN COLD. A SPECIAL COIN MACHINE LUBRICANT IS SUPPLIED WITH EACH MACHINE.

STEP-UP LEVERS, RATCHETS, CAMS, SHAFTS AND OTHER SLIDING OR OSCILLATING PARTS SHOULD BE VERY LIGHTLY GREASED WITH SPECIAL COIN MACHINE LUBRICANT (SUPPLIED WITH MACHINE), NOT OFTENER THAN EVERY SIX MONTHS.

THE BAKELITE DISCS ON THE MOTOR UNITS AND STEP-UP UNITS WILL REQUIRE LUBRICATION WITH THE SPECIAL COIN MACHINE LUBRICANT ONLY AFTER THE GREASE IS COMPLETELY EVAPORATED (3-12 MONTHS, DEPENDING ON CLIMATE), OR WHEN THE FILM OF GREASE BECOMES DIRTY.

IN EITHER EVENT, CLEAN THE PARTS THOROUGHLY WITH A SOLVENT AND A CLEAN, SOFT CLOTH. THEN APPLY AN EXTREMELY THIN COAT OF THE SPECIAL GREASE WITH A FINE, CAMEL'S HAIR BRUSH.

SOLENOID PLUNGERS SHOULD NOT HAVE A LUBRICANT OF ANY KIND. SHOULD THERE BE A SLUGGISH TENDENCY OF IF THE PLUNGERS ARE STICKING, THE PARTS SHOULD BE CLEANED WITH A SOLVENT AND FLAKED GRAPHITE APPLIED ON RE-ASSEMBLY.

SWITCH CONTACTS

THE CONTACT POINTS, AS USED ON THE SWITCHES OF ELECTRO-MECHANICAL GAMES, ARE GENERALLY MADE OF SILVER WHICH HAS A HIGH CONDUCTIVITY OF ELECTRICAL CURRENT.

IN SOME CASES, VARIOUS ALLOYS OF SILVER ARE USED, SUCH AS A COMBINATION OF:

85 %	SILVER
15 %	CADMIUM

OR

83 %	SILVER
17 %	CADMIUM OXIDE

CERTAIN ALLOYS ARE USED FOR SPECIFIC REQUIREMENTS SUCH AS HIGH CURRENT, LOW RESISTANCE, ETC.

IF POINT REPLACEMENT IS NECESSARY, BE SURE TO REPLACE WITH THE PROPER EQUIVALENT.

WHENEVER A REPLACEMENT POINT IS SET, IT IS IMPORTANT THAT THE UNDERSIDE OF THE POINT IS PEENED CAREFULLY SO THAT IT IS SEATED EVENLY AND TIGHTLY. THIS INCREASES THE CURRENT CARRYING CAPACITY TO ITS MAXIMUM EFFICIENCY.

A LOOSE POINT WILL CAUSE ARCING AND BURNING OF THE BLADE; EVENTUALLY THE POINT WILL FALL OUT. WHEN THE CONTACT AREA OF THE POINT BECOMES DIRTY, OR PITTED, A BURNISHING TOOL SHOULD BE USED. FILING OF THE POINTS IS NOT RECOMMENDED, AS THE GROOVES CAUSED BY THE FILE TEND TO INCREASE THE ARCING RESULTING IN A PREMATURELY SHORT LIFE.

THE ELECTRONIC GAMES COME EQUIPPED WITH THE SAME CONTACTS WITH A GOLD PLATED SURFACE. THIS SPECIAL SURFACE IS TO GET A BETTER 'MAKING' UNDER LOW VOLTAGE (5V). SPECIAL CARE SHOULD BE TAKEN IN CLEANING THIS TYPE CONTACT; USE ONLY CLEAN PAPER AS A BURNISHING TOOL.

THE SWITCHES ON THE ELECTRONIC GAME ALSO HAVE A DIODE (IN4004) ON EACH SWITCH, THERE ARE ALSO CAPACITORS (.05MFD) ATTACHED TO SOME OF THE PLAYFIELD SWITCHES.

THESE ARE PRIMARILY ON THE FAST ACTIVATING SWITCHES TO ALLOW EXTRA CLOSURE TIME IN THE CIRCUIT FOR MPU TO READ THE CLOSURE.

SCORE MOTOR UNIT

THE SCORE MOTOR UNIT CONTROLS THE SEQUENCE OF THE VARIOUS CIRCUITS. THIS IS ACCOMPLISHED BY A MOTOR DRIVEN SET OF CAMS THAT OPERATE THEIR RESPECTIVE SWITCHES IN A FIXED PATTERN.

THIS ASSEMBLY IS USED IN EVERY PINBALL GAME AND CONSISTS OF A FRAME, A MOTOR, AND CAMS, MOUNTED ON A COMMON SHAFT; THE CAMS ARE NUMBERED IN SEQUENCE, STARTING WITH #1 CAM CLOSEST TO THE MOTOR. THE CAM SWITCHES ARE LETTERED ALPHABETICALLY, STARTING WITH 'A' FOR THE BOTTOM SWITCH OF A SWITCH STACK.

FOR EXAMPLE, SWITCH '3B, SCM' IS A SWITCH ON THE SCORE MOTOR UNIT (SCM), OPERATED BY #3 CAM (3), AND IS THE SECOND SWITCH (B) FROM THE BOTTOM OF THE SWITCH STACK.

THE MOTOR HAS TO RECEIVE A STARTING PULSE FROM VARIOUS SOURCES; HOWEVER, IT WILL CYCLE ITSELF ONE-HALF REVOLUTION (180° ROTATION) BY MEANS OF MOTOR RUN SWITCH ON #1 CAM.

SCORE MOTOR UNIT (TYPICAL)

COMPONENTS:

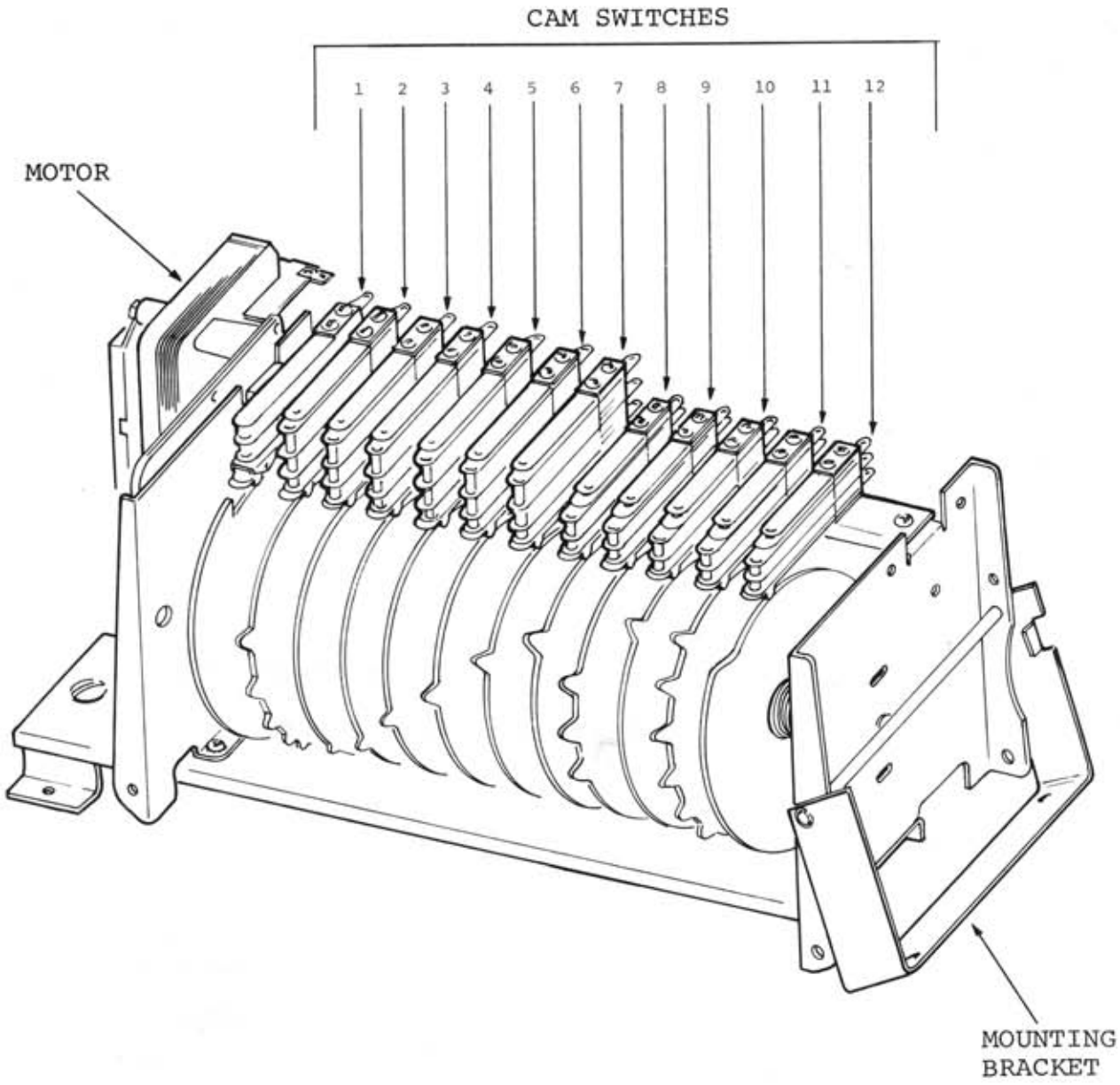
FRAME		
MOTOR	(26 RPM)	(NORMAL CYCLE IS 1/2 REVOLUTION)
CAMS	(11OR 12 CAMS)	
SWITCH ASSEMBLIES		(VARIES WITH GAMES)

PURPOSES:

PROGRAM SEQUENCE
PULSING
TIMING

CAMS		1/2 CYCLE
#1	INDEX CAM ALSO CARRY-OVER FOR MOTOR RUN	(DWELL)
#2	5 PULSE CAM FOR SCORING, RESETTING, ETC.	(5 LOBES)
#3	1 PULSE, SAME AS 1ST OF #2 CAM PULSES	(1 LOBE)
#4	1 PULSE, SAME AS 2ND OF #2 CAM PULSES	(1 LOBE)
#5	1 PULSE, SAME AS 3RD OF #2 CAM PULSES	(1 LOBE)

SCORE MOTOR



CAMS		1/2 CYCLE
#6	1 PULSE, SAME AS 4TH OF #2 CAM PULSES	(1 LOBE)
#7	1 PULSE, SAME AS 5TH OF #2 CAM PULSES	(1 LOBE)
#8	1 PULSE, AFTER 5TH PULSE OF #2 CAM PULSES	(1 LOBE)
#9	3 PULSE, SAME AS 3RD, 4TH, 5TH OF #2 CAM PULSES	(3 LOBES)
#10	1 PULSE, AFTER #8 CAM PULSE	(1 LOBE)
#11	6 PULSE, IN BETWEEN PULSES OF #2 CAM PULSES	(6 LOBES)
#12	ALTERNATING (IF USED) - CAM SWITCH IS CLOSED ON 1/2 REVOLUTION AND OPEN ON OTHER.	

RELAYS (G-TYPE)

PURPOSE

WHEN ELECTRICAL CURRENT FLOWS THROUGH THE COIL, A MAGNETIC FIELD RESULTS. THIS FIELD ATTRACTS THE ARMATURE FLAP AND MECHANICALLY ACTUATES THE SWITCHES. THUS, BY A SINGLE ACTION OF COMPLETING THE CIRCUIT TO THE RELAY COIL, ANY NUMBER OF INDIVIDUAL CIRCUITS CAN BE CONTROLLED THRU THE ASSOCIATED RELAY SWITCHES.

A SINGLE PULSE TO THE RELAY COIL IN CONJUNCTION WITH A LOCK IN SWITCH CAN HOLD IN THE CIRCUITS UNTIL A CERTAIN FUNCTION IS COMPLETED. THIS IS USEFUL IN CASES OF MULTIPLE SCORING, STEPPING-UP OR RESETTING A UNIT OR WHERE A DEFINITE SEQUENCE OF OPERATION IS NECESSARY.

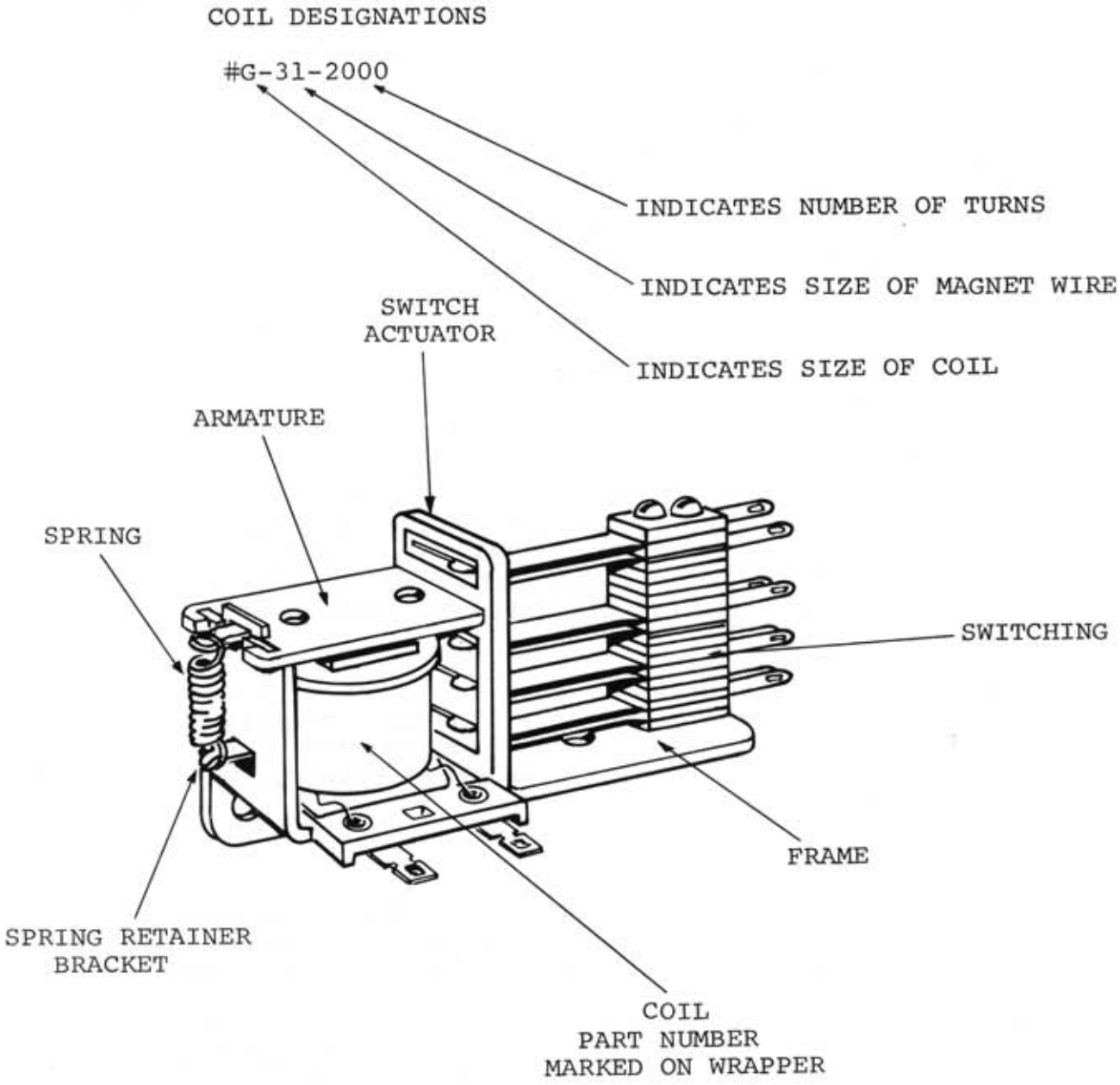
ADJUSTMENTS

THE GAP AND FOLLOW THRU SPECIFICATIONS SHOULD BE USED AS A GUIDE, AND SOME JUDGEMENT MUST BE EXERCISED TO INSURE THAT THE ADJUSTED GAP WILL PERFORM PROPERLY UNDER THE USE CONDITIONS.

ALL SWITCH ADJUSTMENTS MUST ORIGINATE WITH THE PLASTIC SWITCH ACTUATOR IN DE-ENERGIZED POSITION. AFTER SWITCH ADJUSTMENTS ARE COMPLETED, THE ACTUATOR SHOULD AUTOMATICALLY RETURN TO THIS POSITION. ALL SWITCH ADJUSTMENTS MUST BE DONE WITH A STROKING ACTION OF THE ADJUSTING TOOL, WITH NO SHARP BEND AT THE SWITCH SPACERS.

BEFORE ADJUSTING SWITCHES, MAKE SURE THE TIP OF THE LONG BLADES ARE CENTERED IN THE SLOTS OF THE SWITCH ACTUATOR, OTHERWISE THEY WILL HAMPER THE MOVEMENT OF THE SWITCH ACTUATOR.

'G' TYPE RELAYS



TIGHTEN DOWN THE SCREWS THAT HOLD THE SWITCH ASSEMBLY. THIS IS SUGGESTED BECAUSE THE PLASTIC SPACERS IN THE SWITCH STACKS WILL OCCASIONALLY SHRINK BY DRYING OUT, CAUSING A POOR ADJUSTMENT.

WHEN SWITCHES ARE PROPERLY ADJUSTED, THERE SHOULD BE ABOUT 1/32 IN. FOLLOW THRU, EXCEPT IN THE CASE OF LOCK IN SWITCHES, WHICH SHOULD BE SLIGHTLY MORE. THIS 'FOLLOW THRU' ACTION PROVIDES A WIPING MOTION BETWEEN CONTACTS, KEEPING THEM CLEAN.

NORMALLY OPEN SWITCHES

HOLD SWITCH ACTUATOR IN TOP POSITION. ADJUST LONG BLADE SO THE TIP RESTS LIGHTLY (10 GRAMS PRESSURE) ON UPPER SIDE OF SLOT IN PLASTIC SWITCH ACTUATOR.

ADJUST SHORT BLADES TO 1/32 IN. CLEARANCE BETWEEN CONTACT POINTS, EXCEPT IN SWITCH, 1/64 IN. CLEARANCE.

NORMALLY CLOSED SWITCHES

HOLD SWITCH ACTUATOR IN TOP POSITION WHILE ADJUSTING LONG BLADE SO THE TIP RESTS LIGHTLY (10 GRAMS PRESSURE) ON UPPER SIDE OF SLOT IN PLASTIC SWITCH ACTUATOR. IT MAY BE NECESSARY TO ADJUST SHORT BLADE AWAY FROM THE LONG BLADE. HOLD SWITCH ACTUATOR IN DOWN POSITION WHILE ADJUSTING SHORT BLADES TO 1/32 IN. CLEARANCE BETWEEN CONTACT POINTS.

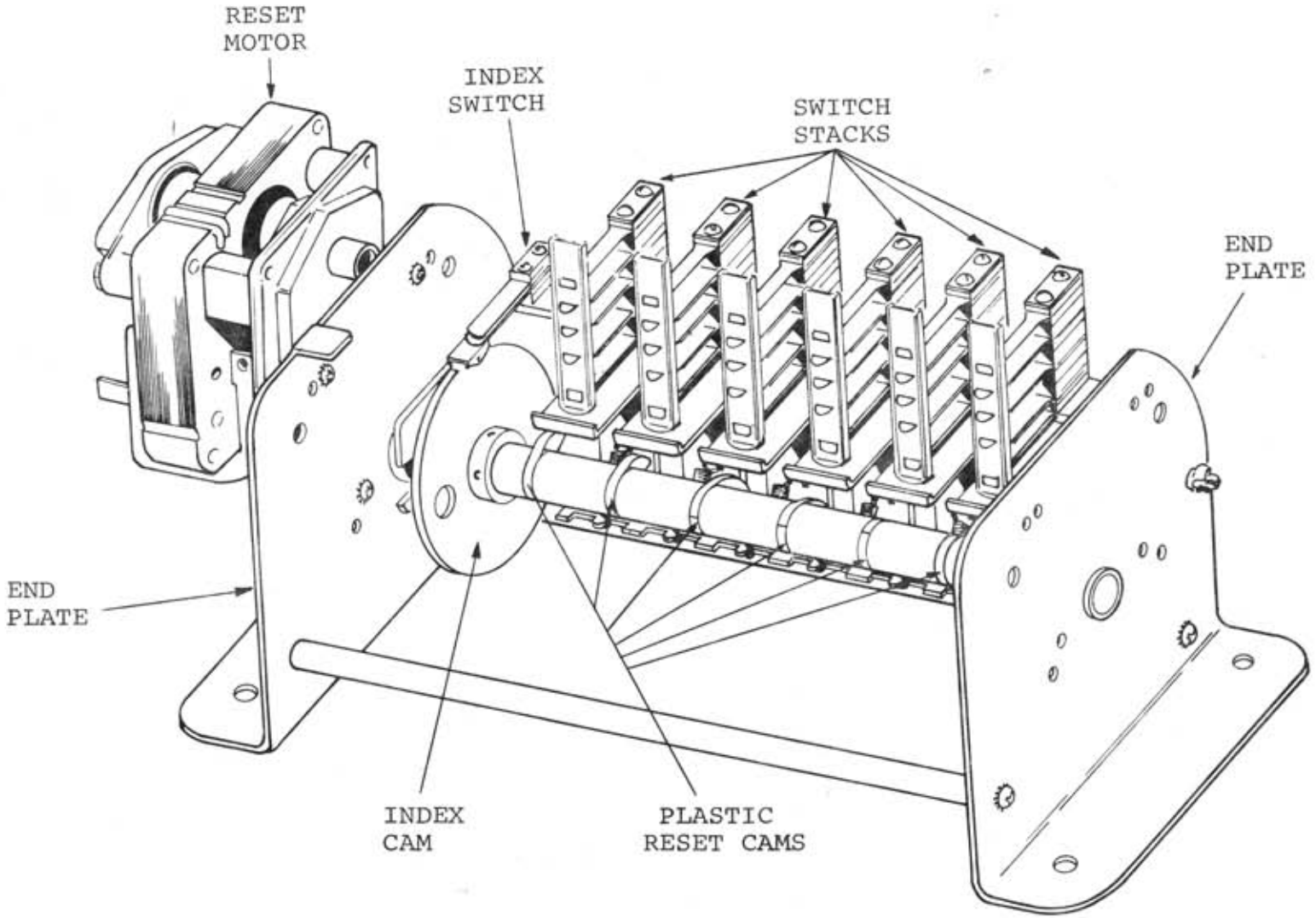
THE ARMATURE SPRING SHOULD HAVE ENOUGH TENSION TO BRING THE ARMATURE UP AGAINST THE ARMATURE STOP WHEN THE RELAY IS NOT ENERGIZED. SEE THAT PRESSURE FROM POORLY ADJUSTED SWITCHES IS NOT AFFECTING THE ARMATURE BEFORE ATTEMPTING ADJUSTMENT ON THE SPRING.

IF A RELAY 'CHATTERS' OR 'HUMS', CHECK TO SEE THAT SWITCHES, LOCATED ON IT, ARE NOT OUT OF ADJUSTMENT AND CAUSING TOO MUCH UPWARD TENSION ON THE ARMATURE. IN SOME CASES, THE TROUBLE CAN BE DUE TO FOREIGN MATTER ON TOP OF THE RELAY COIL CORE. THIS CAN BE REMOVED WITH A SMALL FILE.

MOTORIZED TRIP RELAY BANK

THE MOTORIZED TRIP RELAY BANK ASSEMBLY WAS DESIGNED AND PATENTED BY BALLY, PRIMARILY TO ELIMINATE THE 115 VOLTS FROM THE OPERATING CIRCUITS OF A GAME AND TO INSURE A POSITIVE RESET OF ALL TRIP RELAYS.

A TRIP RELAY BANK CONSISTS OF A NUMBER OF RELAYS ON A



MOTORIZED TRIP RELAY BANK

COMMON FRAME, A MAIN RELAY MOUNTING PLATE, PLASTIC RESET CAMS ON A COMMON SHAFT AND A RESET MOTOR. THE TRIP RELAYS ARE RESET WHEN RESET CAMS ARE OPERATED BY A 50 VOLT MOTOR, USUALLY 35 R.P.M.

EACH CAM RAISES AN INDIVIDUAL RELAY LATCH ASSEMBLY MOMENTARILY, ALLOWING THE ARMATURE TO HOLD IT IN LOCKED POSITION UNTIL THE RESPECTIVE RELAY COIL IS ENERGIZED.

A TRIP RELAY COIL, WHEN ENERGIZED, WILL MAGNETIZE ITS ARMATURE; THUS, 'TRIPPING' (RELEASING) THE LATCH ASSEMBLY TO ACTUATE ITS SWITCHES. THE SWITCHES REMAIN ACTUATED UNTIL RELAY IS RESET, ELIMINATING THE NECESSITY OF A LOCK-IN CIRCUIT FOR EACH RELAY.

WHEN A 'CLUTCH TRIP RELAY' OR RELAYS ARE INCLUDED IN THE ASSEMBLY, IT IS POSSIBLE TO RESET GROUPS OF RELAYS INDEPENDENTLY FROM OTHER GROUPS.

EACH GROUP OF RELAYS HAS ITS OWN INDEX CAM TO INSURE A COMPLETE RESET CYCLE.

THE MAIN RELAY MOUNTING PLATE MAY BE REMOVED FROM THE TRIP BANK ASSEMBLY FRAME BY REMOVING THE THUMB SCREWS FROM THE TWO END PLATES OF THE ASSEMBLY; THEN RAISE THE BACK OF THE RELAY MOUNTING BRACKET WHICH SWIVELS ON THE MAIN SHAFT AND LIFT OFF.

1. TO REPLACE A TRIP RELAY COIL, LATCH ASSEMBLY OR ARMATURE:

(A) REMOVE THE MAIN RELAY MOUNTING PLATE (AS DESCRIBED ABOVE).

(B) TURN MAIN MOUNTING PLATE UPSIDE DOWN. NOTE THAT COILS ARE MOUNTED IN GROUP COIL BRACKETS, 2 OR 3 TO A GROUP.

(C) TO REMOVE A COIL, LATCH ASSEMBLY OR ARMATURE, LOOSEN SCREWS TO ALL COILS IN A GROUP COIL BRACKET. REMOVE NUTS AND LOCK WASHERS THAT SECURE THE BRACKET TO MAIN MOUNTING PLATE.

(D) UNSOLDER BARE JUMPER WIRE ON ALL COILS IN THE BRACKET.

(E) HOLD DOWN LATCH ASSEMBLY AND REMOVE THE COIL BRACKET FROM THE MAIN MOUNTING PLATE.

(F) TO REPLACE ARMATURE OR LATCH ASSEMBLY, FIRST REMOVE THE SPRING.

(G) TO REPLACE THE CENTER COIL OF A 3 COIL GROUP, EITHER REMOVE AN OUTSIDE COIL FIRST, OR REMOVE CENTER ARMATURE SPRING AND ARMATURE.

(H) WHEN REPLACING THE BRACKET-COIL-ARMATURE GROUP BACK ON MAIN MOUNTING PLATE, HOLD DOWN LATCH ASSEMBLIES AND ALSO HOLD ARMATURES AGAINST THE COILS. WHEN ASSEMBLY IS COMPLETED, SOLDER BARE JUMPER WIRES TO COILS.

2. TO REPLACE MOTOR OR CAMS:

(A) REMOVE MAIN RELAY MOUNTING PLATE.

(B) REMOVE 2 SCREWS FROM LONG RODS THAT SECURE END PLATE AND MOTOR.

(C) PULL END PLATE AND MOTOR.

(D) REMOVE 4 MOTOR MOUNTING SCREWS. NOTE: WHEN INSTALLING A NEW MOTOR, BE SURE ROLL PIN ON NEW MOTOR SHAFT IS IN PLACE.

(E) TO REMOVE CAMS WHEN NO CLUTCH IS ON THE ASSEMBLY, PULL THE ENTIRE CAM SHAFT ASSEMBLY FROM OTHER END PLATE. REMOVE 'E' RETAINER RING FROM END OF SHAFT AND CAMS WILL SLIDE OFF. NORMALLY ALL CAMS ARE IDENTICAL.

(F) TO REMOVE CAMS WHEN A CLUTCH IS INCLUDED ON THE ASSEMBLY, REMOVE CAMS AWAY FROM CENTER CAM; DO NOT LOOSEN SET SCREWS ON CENTER CAM UNLESS NECESSARY. TO REMOVE A CLUTCH ASSEMBLY, DRIVE OUT ROLL PIN HOLDING CLUTCH ASSEMBLY.

SWITCH ADJUSTMENT

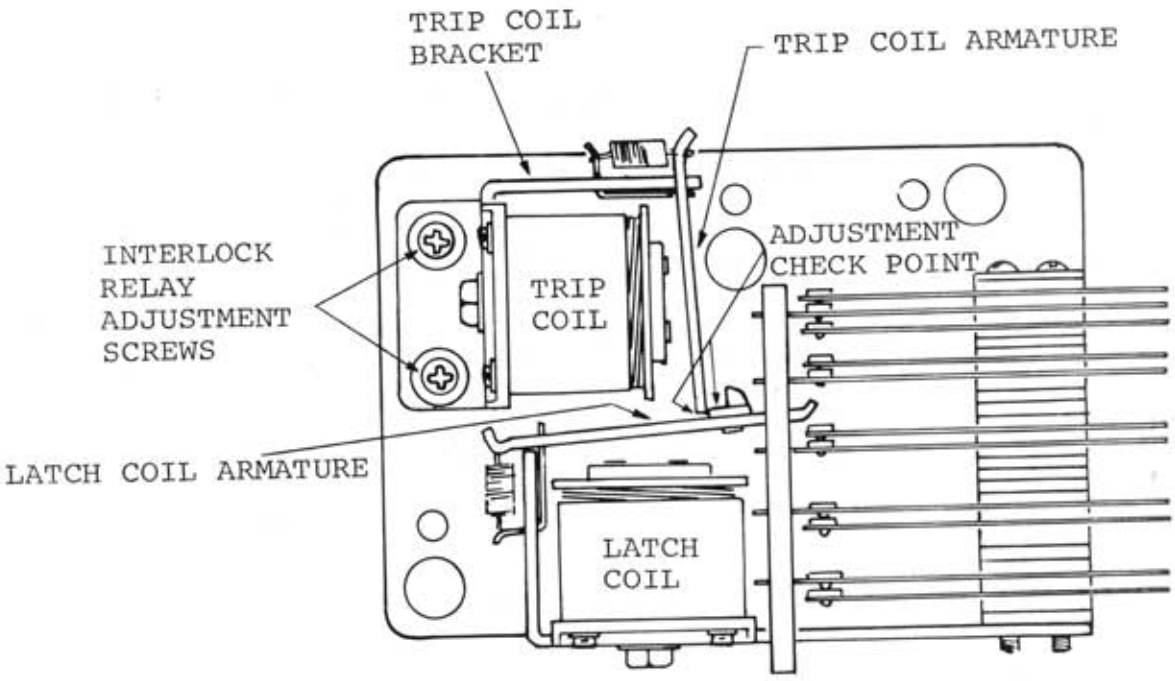
THE SWITCHES SHOULD BE ADJUSTED SO THAT THEY PERFORM THE DESIRED FUNCTION IN BOTH ON AND OFF CONDITIONS. SOME JUDGEMENT SHOULD BE EXERCISED, FOR YOU WANT THE SWITCH TO PERFORM PROPERLY, NOT TO HAVE A UNIFORM GAP SETTING.

BEFORE ADJUSTMENTS ARE MADE, MAKE CERTAIN THAT THE SCREWS HOLDING THE SWITCH STACKS ARE DOWN TIGHT. THE PLASTIC SPACERS IN THE SWITCH STACKS WILL OCCASIONALLY SHRINK BY DRYING OUT. THIS CAUSES A POOR ADJUSTMENT. THE SWITCHES SHOULD BE ADJUSTED WITH A MINIMUM 1/16 IN. GAP AND AT LEAST 1/32 IN. OVER TRAVEL.

DO NOT KINK OR BEND SHARPLY AS THIS WILL CAUSE THE BLADE TO FATIGUE AND LOSE ITS ABILITY TO SPRING BACK. EVENTUALLY, IT MAY FRACTURE AND BREAK. ADJUST BLADES WITH A SWEEPING, BOWING MOTION, WITH A SWITCH BLADE ADJUSTING TOOL.

INTERLOCK RELAY

INTERLOCK RELAY



FUNCTIONALLY, THIS TYPE OF RELAY IS THE SAME AS OTHER RELAYS, DIFFERENT ONLY IN THAT IT IS 'LOCKED IN' MECHANICALLY ALTHOUGH THE COIL IS DE-ENERGIZED.

IT CONSISTS OF A REGULAR RELAY PLUS AN ADDITIONAL COIL AND ARMATURE PLATE, PLACE IN A POSITION SO THAT WHEN ONE COIL IS MOMENTARILY ENERGIZED IT WILL PULL ITS ARMATURE DOWN AND ALLOW THE OTHER ARMATURE TO SLIDE OVER IT; THUS HOLDING IT MECHANICALLY IN THAT POSITION UNTIL THE OTHER COIL IS MOMENTARILY ENERGIZED AND THE PROCESS IS REPEATED IN REVERSE.

THE COIL AND ARMATURE ASSEMBLY CONTAINING THE SWITCH STACK IS CALLED THE 'LATCH' COIL, SOMETIMES REFERRED TO AS THE 'RESET COIL'. THE COIL WITH ONLY THE ARMATURE IS CALLED THE 'TRIP COIL'.

ADJUSTMENT

HOLD THE LATCH ARMATURE DOWN DIRECTLY OVER THE CENTER OF THE LATCH COIL. THERE SHOULD BE A .010 IN. GAP BETWEEN THE TRIP COIL ARMATURE AND THE NYLON PIECE.

HOLD THE TRIP COIL ARMATURE DOWN. THERE SHOULD BE ABOUT .010 IN. BETWEEN THE TWO ARMATURES.

ADJUSTMENTS OF THE GAP ARE MADE BY LOOSENING THE SCREWS HOLDING THE TRIP COIL IN PLACE. BE SURE TO TIGHTEN DOWN THE SCREWS AFTER ADJUSTMENT IS COMPLETED.

THE SWITCH ADJUSTMENTS ARE THE SAME AS THAT FOR A REGULAR RELAY.

STEP-UP UNIT

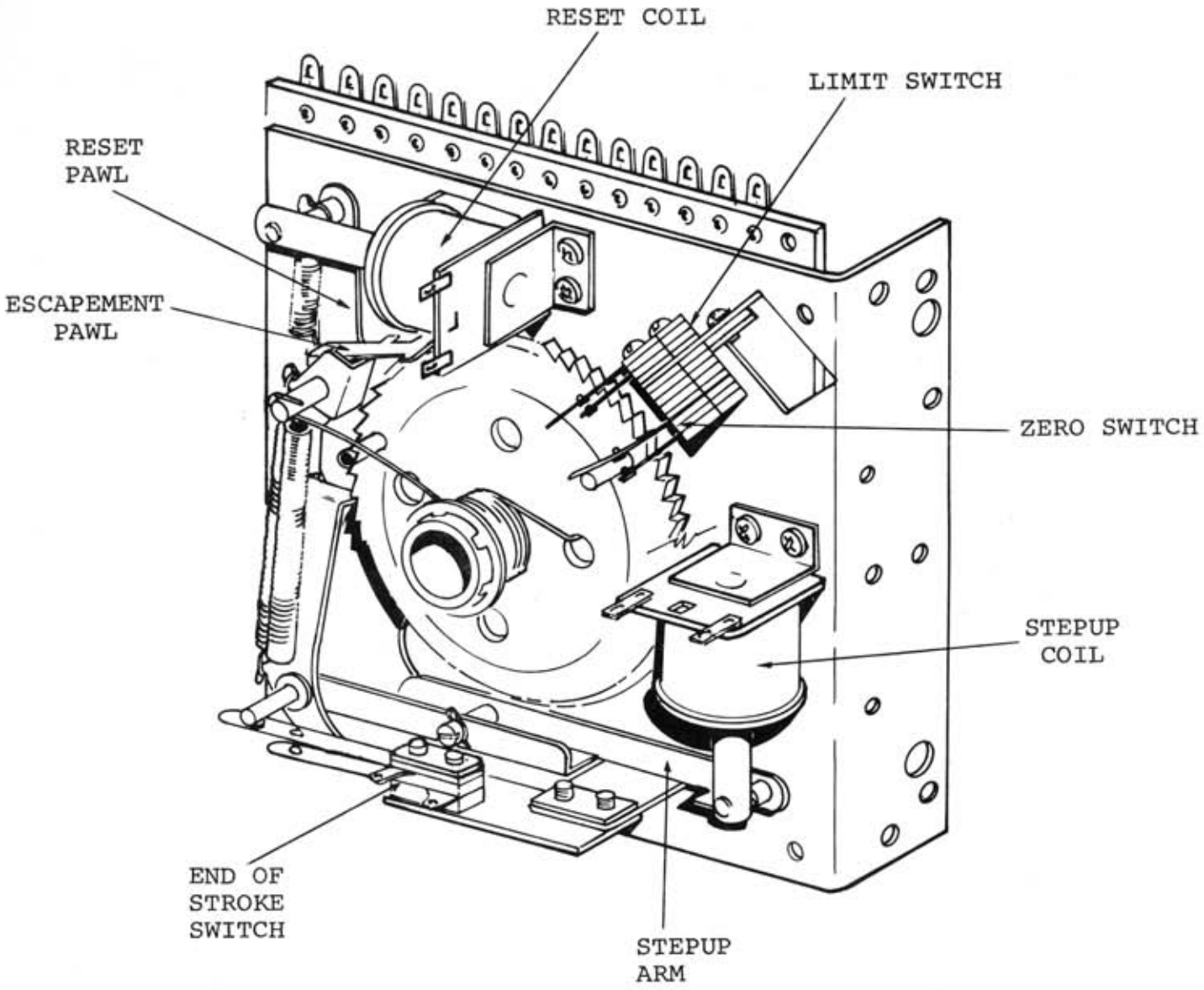
OTHER NAMES:

STEPPER UNIT, ROTARY SWITCHING UNIT, STEP SWITCHER UNIT.

TYPES OF UNITS:

1. CONTINUOUS ROTATION
2. TOTAL RESET
3. ESCAPEMENT RESET (SINGLE STEP RESET)

CONTINUOUS ROTATION UNITS:


RESET COIL
LIMIT SWITCH
RESET PAWL
ESCAPEMENT PAWL
ZERO SWITCH
STEPUP COIL
END OF STROKE SWITCH
STEPUP ARM

STEP-UP UNIT

THIS UNIT HAS ONLYONE SOLENOID WHICH DRIVES THE UNIT IN ONLY ONE DIRECTION. THE SCORE DRUM UNITS AND 00-90 UNITS ARE EXAMPLES OF THIS TYPE OF UNIT.

TOTAL RESET UNITS:

THIS UNIT HAS TWO SOLENOIDS -- ONE TO DRIVE (STEP UP) THE UNIT AND ANOTHER TO RESET THE UNIT TO INDEX (ZERO) POSITION. THE BALL COUNT UNIT, PLAYER UP UNIT ARE EXAMPLES OF THIS TYPE OF UNIT.

ESCAPEMENT RESET UNITS:

THIS UNIT HAS TWO SOLENOIDS -- ONE TO DRIVE (STEP UP) THE UNIT AND ANOTHER TO RESET THE UNIT ONE STEP (POSITION) AT A TIME. THE CREDIT UNIT AND SOME BONUS UNITS, ESPECIALLY THOSE THAT SCORE OVER 500 OR 5000 POINTS, IN INCREMENTS OF 10,000 OR 1,000, ARE THIS TYPE OF UNIT.

PURPOSE OF STEP-UP UNITS:

THESE UNITS SERVE AS A MIXER SEQUENCE UNIT (00-90), COUNTER UNIT (SCORE DRUM UNIT), MEMORY SEQUENCE UNIT (BONUS UNITS), ALTERNATOR UNIT (TWO COIN UNIT), SEQUENCE UNIT (PLAYER UP UNIT), ETC.

THEY ARE SWITCHING UNITS IN THAT THEY MAKE OR BREAK CIRCUITS IN A DEFINITE PATTERN. ACTUAL SWITCHING IS DONE BY WIPER ASSEMBLY MAKING CONTACT WITH WIRED RIVETS OR 'PRINTED CIRCUITS' ON THE BAKELITE DISC.

OPERATION OF UNITS:

STEP-UP (DRIVE) SOLENOID: WHEN THE SOLENOID IS ENERGIZED, THE DRIVE PAWL ENGAGES THE NEXT TOOTH ON THE RATCHET, RELEASES POWER, AND THE DRIVE SPRING ADVANCES THE RATCHET ONE STEP. THE WIPER ASSEMBLY IS ATTACHED TO THE RATCHET SO THE WIPER MOVES FROM ONE RIVET TO THE NEXT. THE INDEX PAWL OR RESET PAWL HOLDS THE RATCHET IN A POSITION UNTIL THE DRIVE PAWL MOVES THE RATCHET TO THE NEXT POSITION.

TOTAL RESET UNIT:

STEP-UP OPERATION IS THE SAME AS ABOVE. THIS UNIT HAS A RESET SOLENOID AND PLUNGER WHICH, WHEN ENERGIZED, OPERATES THE RESET (INDEX) PAWL TO DISENGAGE THE DRIVE PAWL AND MECHANICALLY LOCKS ITSEL AND DRIVE PAWL AWAY FROM THE RATCHET. THE TORSION SPRING (NONE ON CONTINUOUS RETATION UNITS) IS ATTACHED TO THE RATCHET TO RETURN THE RATCHET BACK TO INDEX (ZERO) POSITION.

ESCAPEMENT RESET UNIT:

STEP-UP OPERATION IS THE SAME AS ABOVE. THIS UNIT HAS A RESET SOLENOID AND PLUNGER AS ON THE TOTAL RESET UNIT. THE MAIN DIFFERENCE BETWEEN THE TOTAL RESET UNIT AND ESCAPEMENT RESET UNIT IS THAT THE ESCAPEMENT RESET UNIT HAS AN ESCAPEMENT PAWL AND SPRING WHICH ALLOWS THE RATCHET TO RESET ONLY ONE POSITION EACH TIME THE RESET SOLENOID IS ENERGIZED. THE ESCAPEMENT PAWL DOES NOT LOCK IN DISENGAGED POSITION. TO TOTALLY RESET THIS UNIT, IT IS NECESSARY TO PULSE THE RESET SOLENOID UNTIL THE UNIT IS IN INDEX POSITION.

WIPER ASSEMBLIES:

TYPE OF WIPERS:

1. GROUNDED TO FRAME
2. COPPER DISC FEED
3. INSULATED
4. EXTERNAL WIRE FEED

GROUNDED TO FRAME WIPERS:

THESE WIPER BLADES MAKE CONTACT WITH METAL SPACERS ON THE WIPER ASSEMBLY, WHICH, IN TURN, ARE GROUNDED TO THE UNIT FRAME THROUGH A WIPER FINFER. THE FRAME IS FED BY A WIRE SOLDERED TO A SOLDER LUG WHICH IS SCREWED TO THE FRAME.

COPPER DISC FEED WIPERS:

THE FEED TO THESE WIPERS IS A COPPER DISC ON THE WIPER ASSEMBLY WHICH IS FED BY A WIPER BLADE THAT IS RIVETED TO THE BAKELITE DISC AND WIRED TO A SOLDER LUG ON THE DISC. THESE WIPERS ARE INSULATED FROM THE METAL SPACERS BY BAKELITE SPACERS.

INSULATED WIPERS:

THESE WIPERS ARE GENERALLY PAIRED AND THEY ARE INSULATED FROM OTHER BLADES BY BAKELITE SPACERS OF THE WIPER ASSEMBLY. ONE WIPER IS FED BY A RIVET, COMPLETING THE CIRCUIT TO ANOTHERWIPER AND RIVET.

EXTERNAL WIRE FEED WIPERS:

THIS TYPE OF WIPER CAN ONLY BE USED ON THE RESET TYPE OF UNIT. THE FEED TO THESE WIPERS IS A SPRING SHIELDED CABLE MOUNTED ON THE ASSEMBLY. ONE END OF EACH WIRE IS SOLDERED TO A SOLDER LUG WHICH MAKES CONTACT WITH THE

WIPER BLADE, AND THE OTHER END IS SOLDERED TO A SOLDER LUG MOUNTED ON THE DISC, OR AN AUXILIARY BAKELITE STRIP.

SWITCHES

END-OF-STROKE SWITCH:

THIS SWITCH IS ACTUATED BY THE DRIVE ARM ABOUT THE TIME THE DRIVE PAWL HAS ENGAGED THE NEXT TOOTH OF THE RATCHET.

ZERO SWITCH: (USED ONLY ON RESETTING UNITS)

THIS SWITCH IS ACTUATED BY A PIN ON THE RATCHET WHEN THE UNIT IS IN INDEX POSITION. THIS SWITCH SHOULD BE ADJUSTED SO THAT IT DOES NOT RESTRICT THE MOVEMENT OF THE RATCHET IN ANY WAY.

LIMIT SWITCH: (USED ONLY ON RESETTING UNITS)

THIS SWITCH IS ACTUATED BY A PIN OR POST ON THE RATCHET WHEN THE UNIT HAS ADVANCED TO ITS MAXIMUM POSITION. THIS SWITCH SHOULD BE ADJUSTED SO THAT IT DOES NOT RESTRICT THE MOVEMENT OF THE RATCHET AS THE UNIT ADVANCES INTO THE LAST POSITION.

CREDIT OR RELAY UNIT

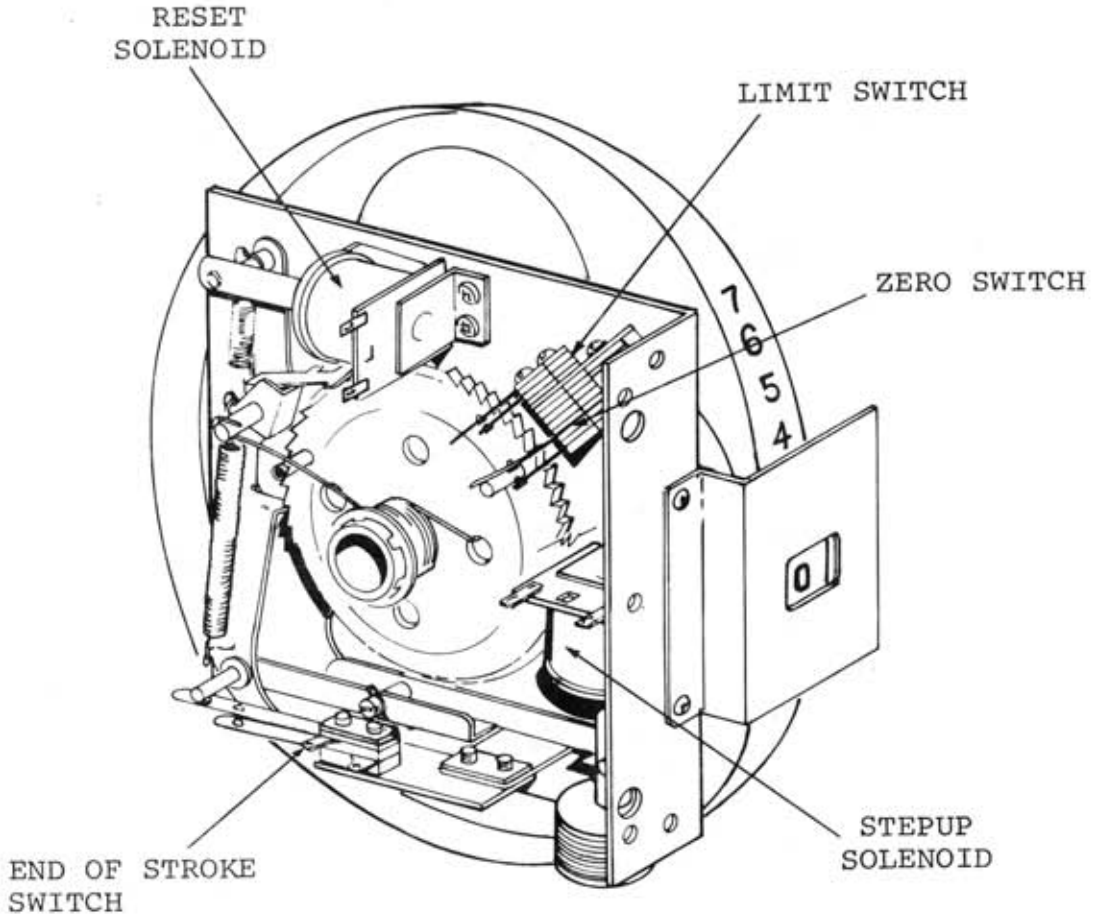
THE CREDIT UNIT IS AN ESCAPEMENT RESET STEP-UP UNIT WITH A NUMBERED REEL. THE REEL INDICATES THE NUMBER OF CREDITS REMAINING.

THE CREDIT UNIT IS ADVANCED BY COINS PASSING THRU COIN CHUTES AND WHEN CREDITS ARE EARNED DURING PLAY OF GAME (WHEREVER NOT PROHIBITED BY LAW), TWENTY-FIVE CREDITS IS THE MAXIMUM LIMIT OF CREDITS AVAILABLE. (ADJUSTABLE FOR LESSER AMOUNTS.)

THE CREDIT UNIT IS RESET ONE CREDIT AT A TIME WHEN THE CREDIT CUTTON IS USED TO SET UP A GAME OR INCREASE THE NUMBER OF PLAYERS ELIGIBLE TO PLAY, WITHIN LIMITATIONS OF THE GAME.

THIS UNIT HAS A ZERO SWITCH WHICH 'OPENS' WHEN NO CREDITS REMAIN. WHEN THIS SWITCH IS 'OPEN', IT MAKES THE CREDIT BUTTON SWITCH INOPERATIVE. THE UNIT HAS A LIMIT SWITCH WHICH 'OPENS' THE CIRCUIT TO THE SETP-UP SOLENOID. THIS UNIT ALSO HAS AN END-OF-STROKE SWITCH WHICH OPERATES THE SOUNDER (KNOCKER) TO INDICATE -- AUDIBLY -- WHEN A CREDIT HAS BEEN ADDED.

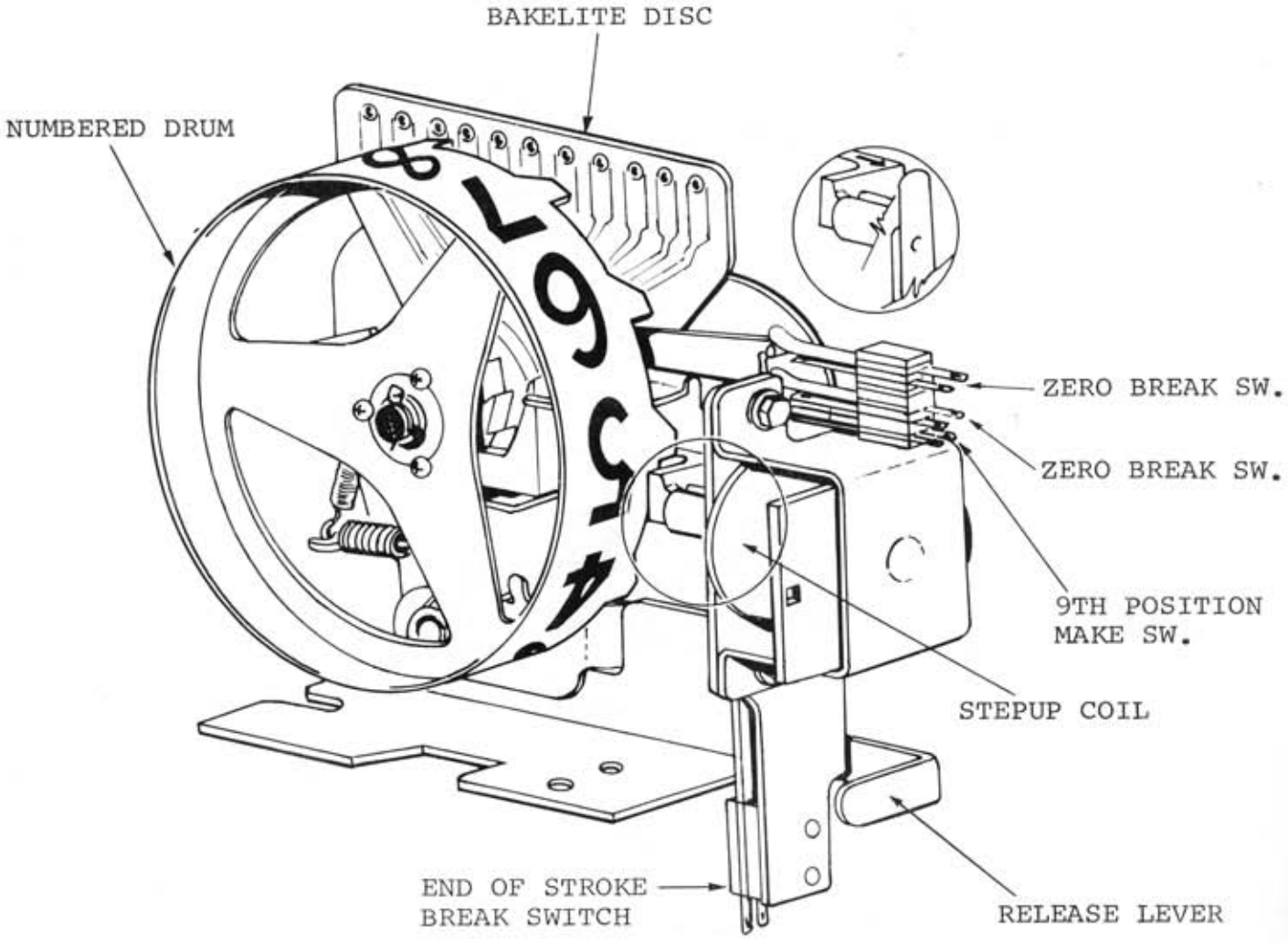
CREDIT UNIT


RESET
SOLENOID
LIMIT SWITCH
ZERO SWITCH
7
6
5
4
0
END OF STROKE
SWITCH
STEPUP
SOLENOID

SCORE DRUM UNIT

To add and accumulate the players score, a number of drum units are used. These are 10 position, continuous rotation, type of step up units, with an attached plastic drum numbered from 0 to 9. Some drum units also have a 10 position bakelite disc and wiper assembly, for additional circuit applications. A switch that opens at the zero position allows the unit to be "cleared" to zero or index position, for the start of a new game. Another switch that opens at zero allows the reset relay (or start relay) to remain energized to guarantee that all drum units "clear" to zero.

During the course of the play of the game, a ninth position make switch is used so that the unit's next pulse will also advance the adjoining drum unit; for example score of 19 to a score of 20. An end of stroke break switch is used to break the lock-in circuit of the point relay. The lock-in circuit is used to insure a proper advance of the drum unit.



SCORE DRUM UNIT

ROLL-OVER WIRE

Roll-over wire forms serve as levers that when actuated by a ball on the playfield, operate switches mounted beneath the playfield. The wire forms come in various sizes and shapes. They are also designated as right or left roll-over wire forms.

ADJUSTMENT

First, be sure that the wire form is centered in the slot in the playfield. Second, the long blade of the switch should be adjusted to hold the wire form snug to the bottom of the playfield. Too much tension will hang up the ball in play.

Normally open switches: Adjust short blade so there is 1/16" gap between contacts. Then place ball on highest point of wire form, there should be approximately 1/32" follow thru after contacts are closed. With cabinet leveled, playfield should have a 3½ pitch. Place ball in the rest position so that the ball comes in contact with wire form and playfield at the same time. Release ball, if switch pressure is correct, ball will pass over wire form causing the switch to score. Under no condition should the ball stop on the wire form, since this may cause a coil to burn out.

Normally closed switches: The short blade should be adjusted so that there is a gap of about 1/64" between contacts when ball is on highest point of wire form.

To prevent switch vibration a special blade is used. It should be adjusted so it is just barely in contact with the short blade, to act as a damper. For an additional test, the playfield may be jarred with the hand to check for switch vibration.

TARGET SWITCHES

Target switches are mounted on the playfield, and are actuated by the ball hitting the plastic target. They may have two (2) or three (3) blades.

ADJUSTMENT

The front blade (the one in which the plastic target is mounted), should be formed so it is touching the end of the slot in the playfield. Doing this will dampen front blade vibrations. The spacing between contacts should be 1/16" and 1/32" follow thru. Do not kink or bend sharply as this will cause the blade to fatigue and break. Adjust blades with a sweeping, bowing motion, with a switch adjusting tool.

ROLL-OVER BUTTON (star type)

This roll-over button assembly consists of a plastic insert that acts as a seat for the roll-over button and its stem. As the actuated switch blade is directly on this stem, there is no leverage advantage as in the roll-over wire form type of actuator. Therefore, a careful switch adjustment is necessary.

ADJUSTMENT

The actuated blade is adjusted so as to apply a slight pressure on the button. The short blade is adjusted for a gap of approximately 1/32" and a 1/32" follow thru.

The anti-vibration blade should be just barely touching the short contact blade.

With the playfield secured in a normal operating position, it is advisable to strike the playfield, to check for vibration of the switch.

It should also be tested by placing a ball at the top edge of the button to check that the ball does not hang up.

ROLL-OVER BUTTON (round button type)

This roll-over button assembly consists of a metal bushing screwed into the bottom of the playfield, and a round white plastic button with a stem. As the actuated switch blade is directly on this stem, there is no leverage advantage as in the roll-over wire form type of actuator. Therefore, a careful switch adjustment is necessary.

ADJUSTMENT

Using a heavy switch bracket adjusting tool or long nose pliers, bend switch stop bracket so that the button is flush with the top of the playfield.

The actuating blade is adjusted so as to apply a slight pressure on the button. The short contact blade is adjusted for a gap of approximately 1/32" and a follow thru of 1/32". The anti-vibration blade should be just barely touching the short contact blade.

With the playfield secured in a normal operating position, it is advisable to strike the playfield, to check for vibration of the switch.

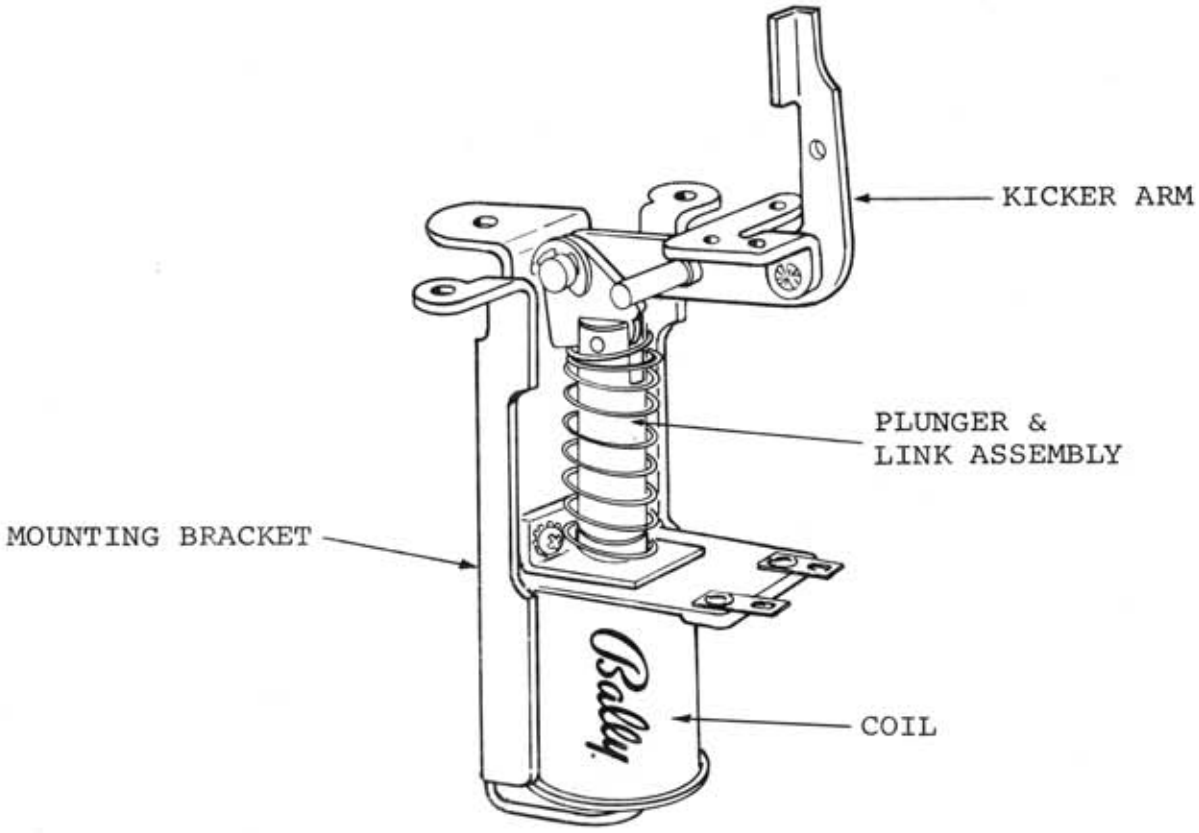
It should also be tested by placing a ball at the top edge of the button to check that the ball does not hang up or fail to score.

SLING-SHOT

The sling-shot is a solenoid operated kicker, that is usually located near the bottom of the playfield. The solenoid is energized by the ball hitting the rubber ring which in turn actuates the switch.

ADJUSTMENT

When sling-shot kicker is at rest, actuating blade of switch should just barely touch the rubber ring, with 1/16" gap between switch points.



RUBBER REBOUND SWITCH

Adjustment: Adjust the switch the same as for the sling-shot.

MUSHROOM BUMPER

Mushroom bumpers consist of a plastic cap with a stem, which directly actuates the switch. The spring loaded cap is housed in a post, which is fastened to the playfield. When a ball comes in contact with the cap, it is raised up, allowing the switch to close.

ADJUSTMENT

The short contact blade is adjusted for a gap of 1/32" when the plastic cap is in the normal position. (push cap down to make sure it is in the normal position).

Lift the plastic cap by hand, and adjust the long contact blade for a good solid contact with the short blade.

Be sure that the plastic cap returns to its normal position.

With the playfield secured in the normal operating position, it is advisable to strike the playfield, to check for vibration of the switch.

BUMPER TARGET

A bumper target is a plastic assembly that will cause a ball to rebound and register a score. When a ball rolls on the plastic disc, the attached stem actuates a cup-shaped switch beneath the playfield.

ADJUSTMENT

Make sure that the stem is in the center of the cup of the switch.

The bumper contact switch should be adjusted with a gap of 1/32" and a follow-thru of 1/32".

THUMPER BUMPER (AC type)

A thumper bumper is an illuminated plastic assembly with a metal and a plastic disc around its body. When a ball rolls on the plastic disc, the attached stem actuates a cup-shaped switch beneath the playfield. This switch energizes a thumper bumper relay which is held energized by its own lock-in switch and the normally closed thumper bumper solenoid end-of-stroke switch. Another switch on the thumper bumper relay, when energized will energize the thumper bumper solenoid which in turn pulls the metal ring down, kicking the ball away from the thumper bumper.

The purpose of the thumper bumper relay is to insure a full stroke of the thumper bumper solenoid, and a third switch on the relay activates the scoring.

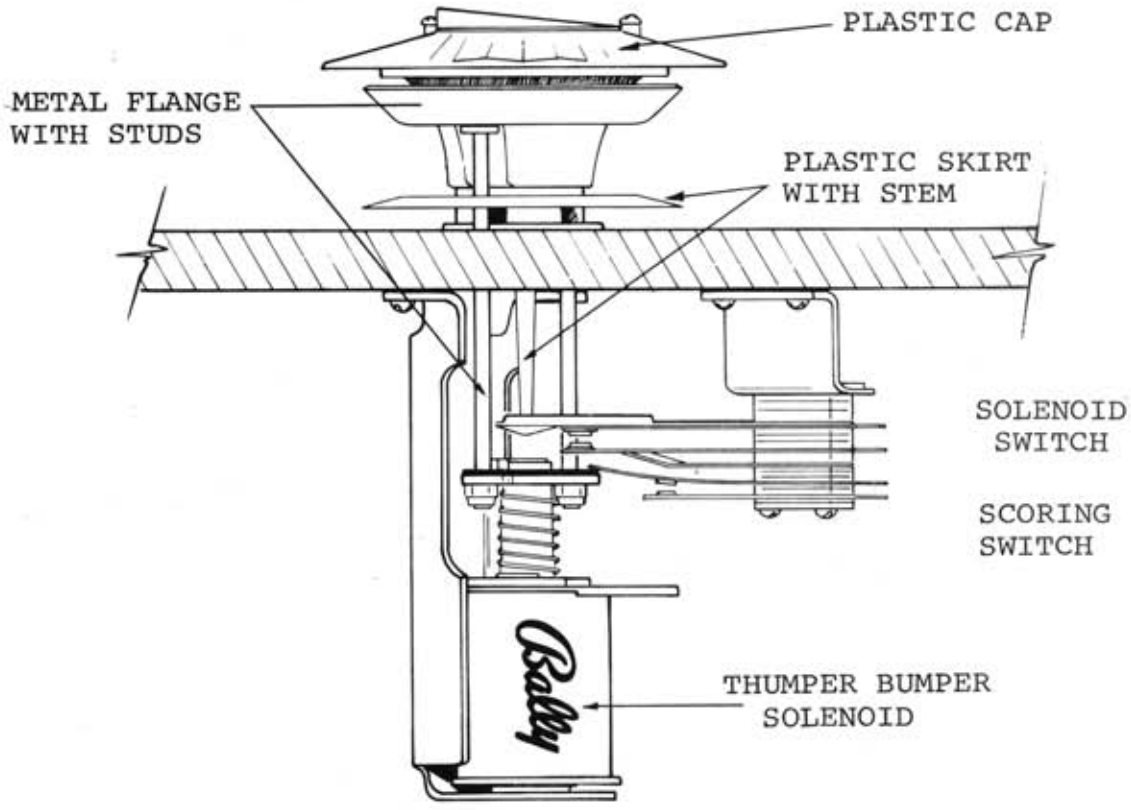
ADJUSTMENT

The thumper bumper solenoid end-of-stroke should be adjusted to have a minimum of 1/32" follow thru when plunger is pulled down. In any case, the switch must open when the plunger is pulled all the way down, otherwise the thumper bumper relay switch will keep the thumper bumper solenoid energized.

The bumper contact switch should be adjusted with a gap of 1/32" and a follow thru of 1/32". To insure best bumper action, the stem attached to the plastic disc should be centered in the cup of the switch. This also insures that the stem will not lock the switch closed. Lo-torque instrument grease should always be in the cup of the switch. (available at your Bally distributors, however, never use vaseline). This will prevent excessive wear of stem and cup.

THUMPER BUMPER (DC type)

The DC (direct current) type thumper bumper is very similar to the AC (alternating current) type, except that it is operated directly by its own contacts, therefore, no relay is used.



THUMPER BUMPER (D.C. TYPE)

ADJUSTMENT

The bumper contact switch should be adjusted with a gap of 1/32" and a follow thru of 1/32".

The other switch is the scoring switch, which should have a gap of 1/16" when the bumper is in the normal position.

ADJUSTMENT (continued)

To insure best bumper action, the stem attached to the plastic disc should be centered in the cup of the switch. This also insures that the stem will not lock the switch closed. The DC type thumper bumper does not need lubrication in the cup of the switch, because the cup is made of self lubricating plastic.

FLIPPERS

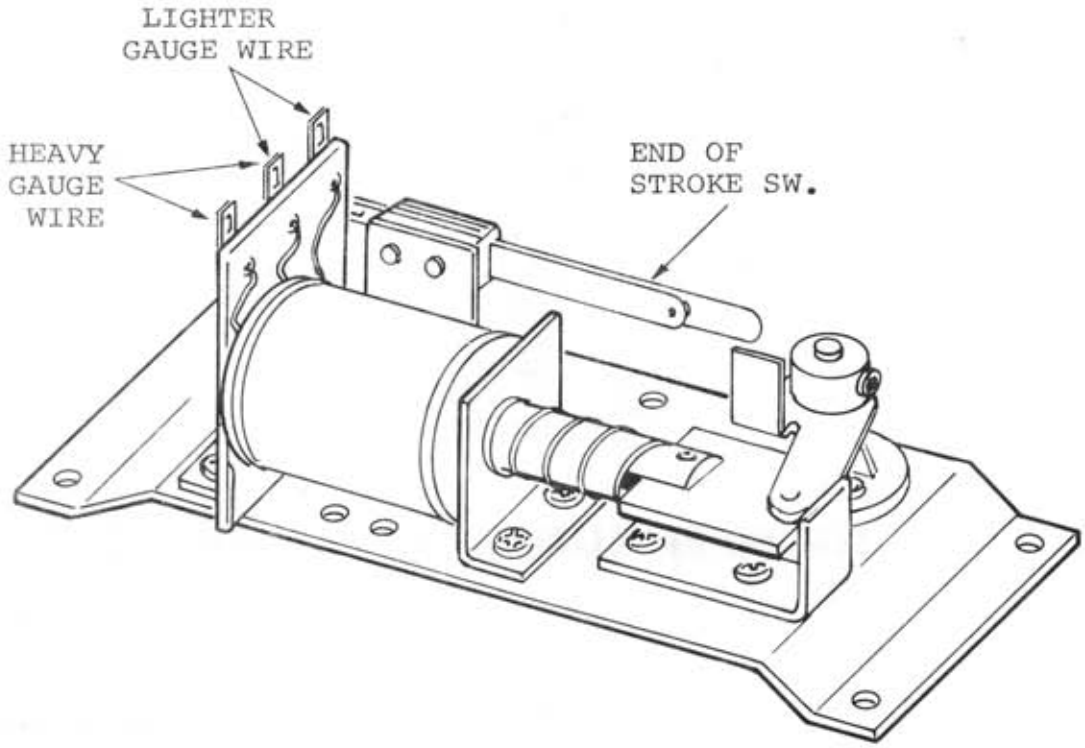
A flipper is an electrically driven bat-type device. A push button on each side of the cabinet allows the player to bat the ball with an element of skill.

The flipper solenoid is a double wound coil. The pull-in winding is a strong winding, constructed of a heavy gauge wire, to insure a fast pull-in. The hold-in winding is a weaker winding, constructed of a lighter gauge wire. When the plunger is pulled-in, a solenoid end-of-stroke switch is opened to cause the circuit to go thru both windings, thus preventing a solenoid burn out when the flipper button is held in.

ADJUSTMENT

The solenoid end-of-stroke switch should be adjusted so that when the plunger is completely depressed manually, the short blade should be adjusted for a gap of 3/32" and a follow thru of 1/32".

The only lubrication required on the flipper unit is the linkage. DO NOT LUBRICATE PLUNGER.



CLOSE FLIPPER or ZIPPER FLIPPER ASSEMBLY

The close flipper assembly moves the flipper assemblies together to stop the ball from going into the outhole, thereby allowing the player added playing time. Basically this assembly consists of a solenoid to move the flipper assemblies together, a switch assembly to lock-in-the circuit until the solenoid has mechanically latched the assembly in the closed position and a release coil to unlatch the spring loaded linkage to move the flippers back to their normal positions.

ADJUSTMENT

The solenoid end-of-stroke switch should be adjusted so when the plunger is completely depressed manually, the short blade should be adjusted for a gap of 3/32" and a follow thru of 1/32". The only lubrication required on the flipper unit is the linkage. DO NOT LUBRICATE PLUNGER.

3 BALLS IN PLAY GAMES

3 Balls-in-play games have proved very popular. It involves ball or balls held captive on the playfield until another ball performs a certain function to release the captive ball or balls thus it is possible to have 3 balls in motion on the playfield at one time.

A game of this type requires some special equipment and consequently special circuits to operate them. First of all, the game must be able to establish the position or location of each ball. When a ball becomes captive and the other two balls are out of play, a ball must be released to the shooter alley so that the same player may continue to play. The game must be able to determine when a play is completed so that the next player may play, or in case there is only one player, the game must advance the ball count unit.

BALL TROUGH ASSEMBLY FOR 3 BALL GAME

This assembly has three trough switches to indicate when there are 3 balls in the trough. When there are 3 balls in the trough, the ball release relay is energized which in turn energizes the ball release solenoid to release one ball, except when the game is over. When there is a captive ball on the playfield, the captive ball switch takes the place of the 3rd trough switch, and when there is a 2nd captive ball on the playfield, the 2nd captive ball switch takes the place of the 2nd trough switch. The ball trough switches must be adjusted so that the ball rolling down the trough will not make two switches at one time. The switches must not be adjusted so tight as to hold back a ball, no matter how slowly the ball rolls.

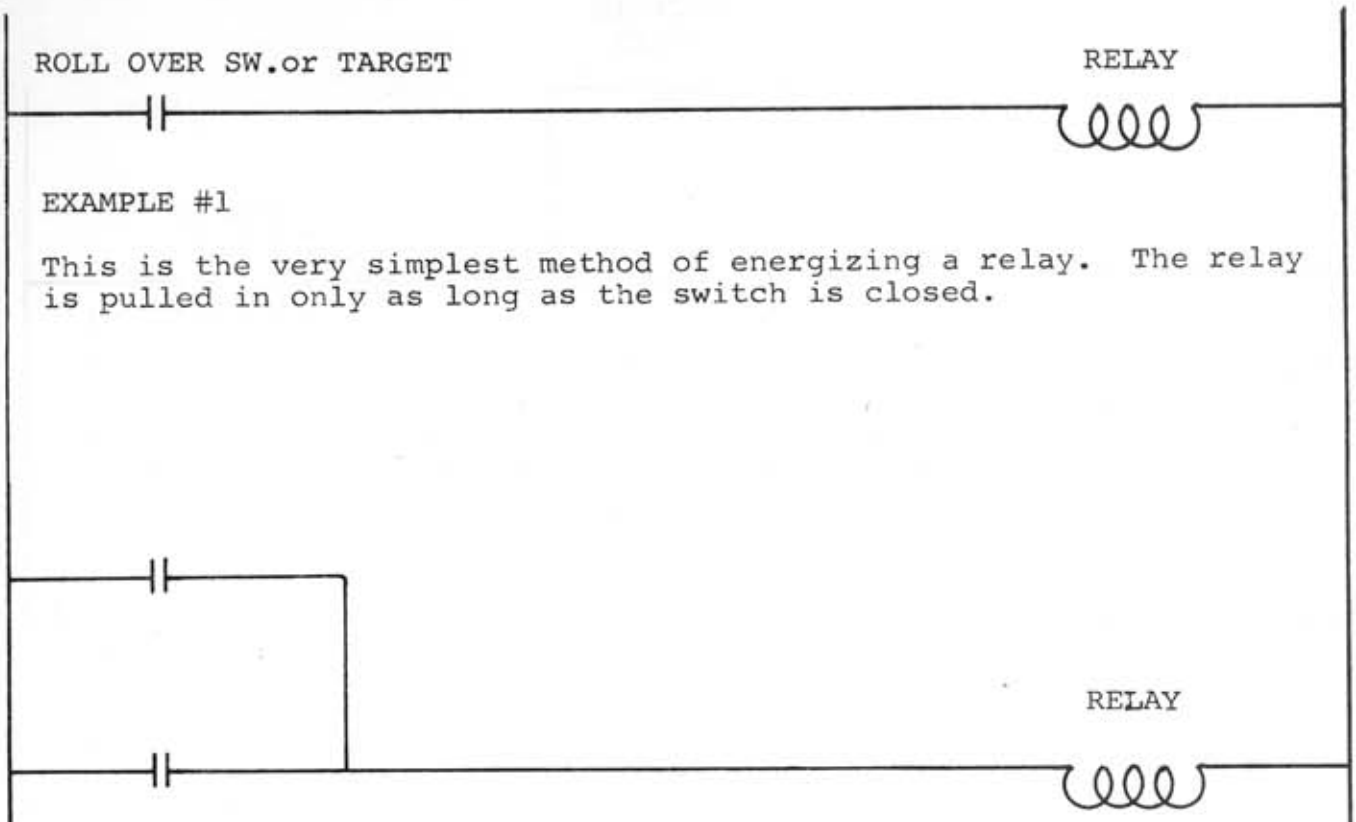
Spring loaded ball retainer pawls (3) on the side of the ball trough prevents a fast ball from bouncing back in the trough, causing the game to mal-function, such as failing to deliver a ball or delivering an extra ball.

BALL RELEASE ASSEMBLY

This assembly is used only in a 3 ball game and operates only when the 3rd ball is out of play, at which time it releases a ball from the ball trough except on game over. The first ball in the trough should stop inside notch of release cam. The cam is positioned by 2 set screws. After adjustment, push in plunger manually, the ball should kick out before the plunger bottoms. After adjustment, the set screws must be screwed in tight.

CAPTIVE BALL ESCAPEMENT ASSEMBLY

The captive ball escapement assembly was designed and patented by Bally. It is mounted under the playfield with escapement pawls extended thru the playfield in such a manner that the ball in the captive ball alley will advance one position at a time. The escapement pawls are hinged on a single bar which is attached to a plunger. A solenoid when energized pulls the plunger allowing the captive ball to advance to the next position and eventually to leave the captive alley.

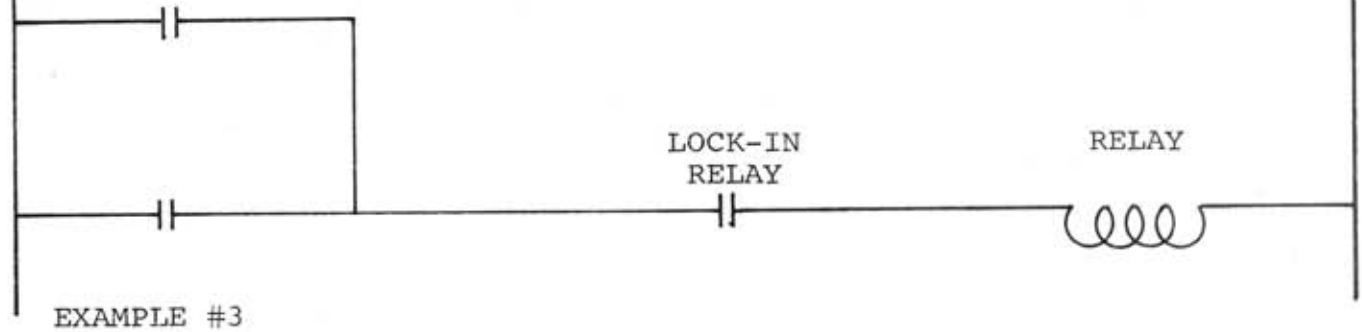


EXAMPLE #1

This is the very simplest method of energizing a relay. The relay is pulled in only as long as the switch is closed.

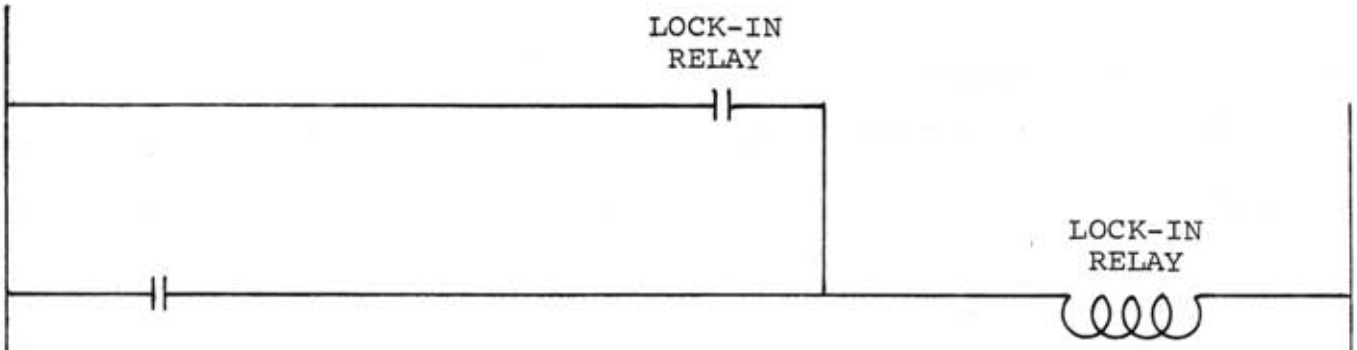
EXAMPLE #2

The operation of example 2 is identical with example 1 except that either switch will pull in the relay.



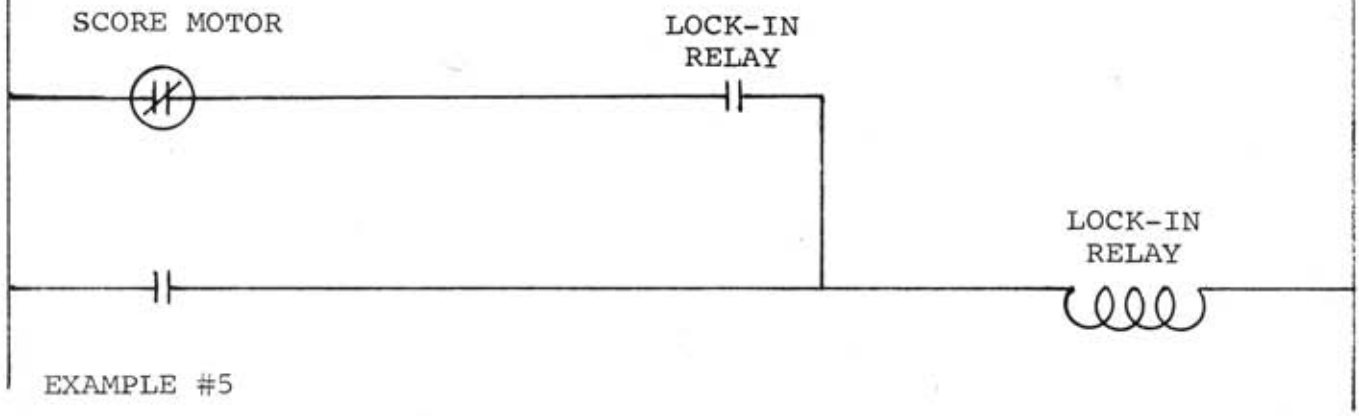
EXAMPLE #3

The only difference with example 3 from 2 is that the hold relay switch must be closed to complete the circuit.



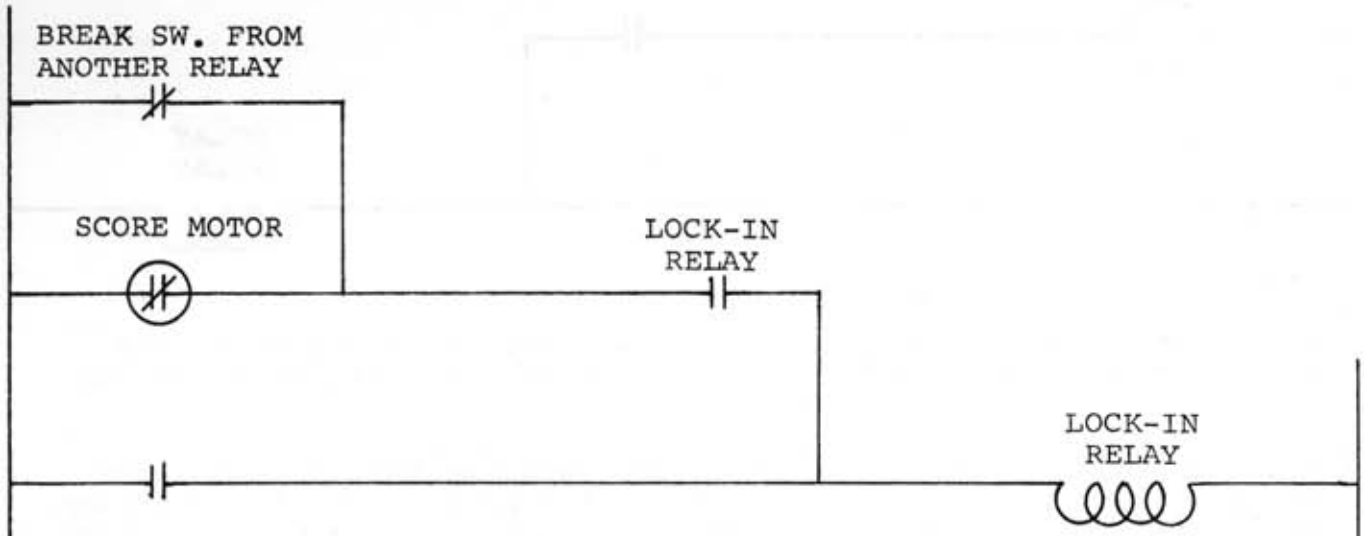
EXAMPLE #4

This is the basic form of a lock-in or hold relay. Once the relay is energized, the only way to de-energize it would be to remove the voltage source.



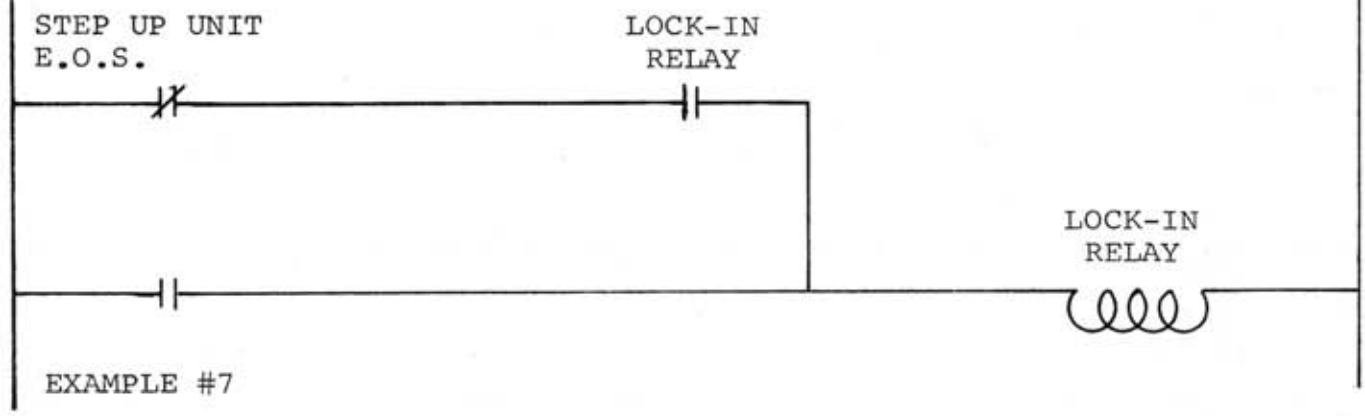
EXAMPLE #5

This lock in circuit will drop out when ever the score motor turns. The score motor switch is usually a #8 or #10 cam switch.



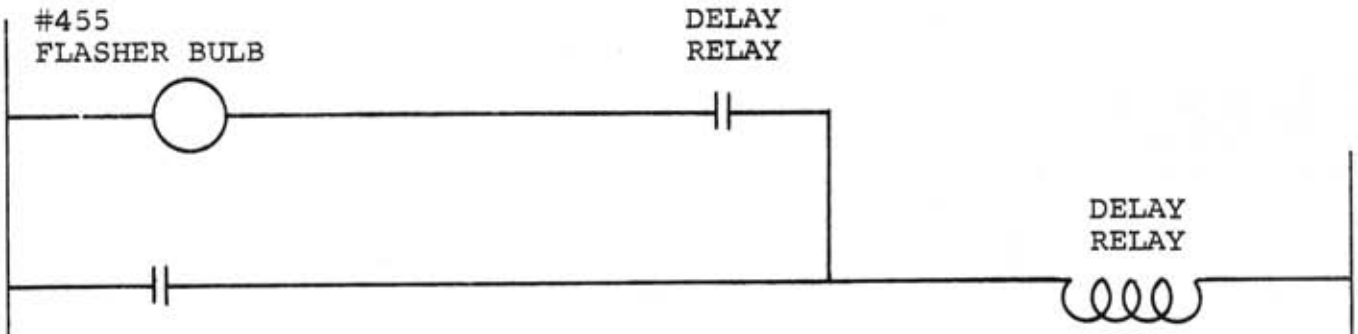
EXAMPLE #6

In this circuit the relay will not drop out with each score motor index. The drop out can be delayed because of the other switch in parallel with the score motor switch. The break switch from the other relay must open before and remain open until after the score motor impulse.



EXAMPLE #7

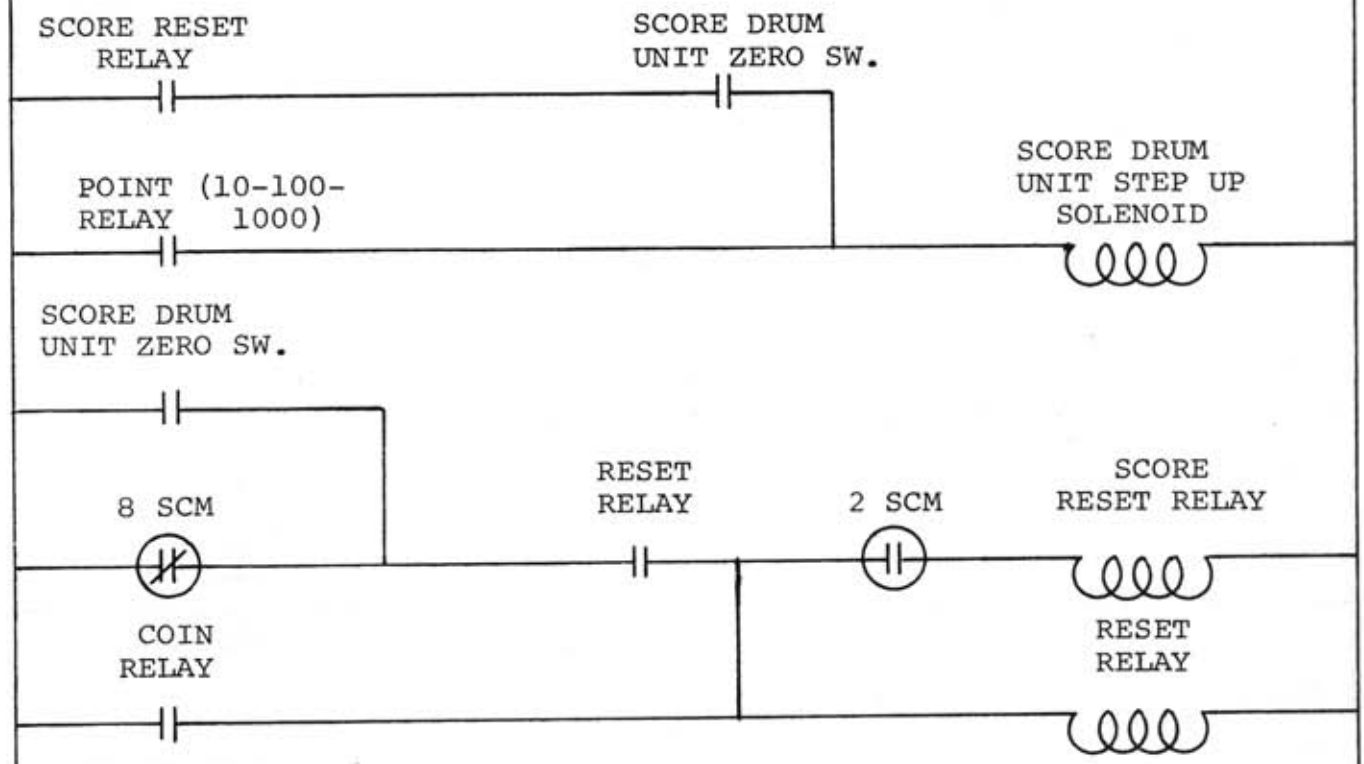
The relay is locked in through a step up unit end of stroke switch. The step up unit must advance for the relay to drop out. A typical example of this circuit is in the point relay (10,100,1000) lock in circuits.



EXAMPLE #8

The delay relay circuit used in Bally games are actuated by the slam switches located on the front door cabinet left side, and on the mounting or bottom board.

When the game is abused, the weighted switches pull in the delay relay. The relay is locked in by the filament of the flasher lamp. As the filament of the lamp heats up, the internal bimetal contacts open the lamp circuit causing the relay to drop out.



EXAMPLE #9

When the coin relay switch is closed, the reset relay is pulled in starting the score motor. The reset relay will stay locked in until all the score drum units advance to zero, and when #8 score motor cam switch is actuated. As long as the reset relay is energized, the score reset relay will pulse thru #2 score motor cam.
During the game reset time the score drum units will advance until the score drum units zero switch opens.

INTRODUCTION TO SERVICING

More damage can be done by unnecessary adjustments and probing before first considering what could have caused the trouble. Most operations are more or less standard on all games. The sequence of operations are also more or less standard.

(1) Start of a game:

(a) At start of a game, the coin (start) relay must first be energized.

(b) Functions of the coin relay:

Operates the score motor
Energizes the reset relay, which in turn causes the score reset relay(s) to pulse thru the #2 and/or #11 score motor cam switches to reset the score drum units.

Resets the ball count unit.

Resets the credit unit, if credit was used to start the game.

Latches the game over relay.

On a 4-player game, resets the player up unit and the coin unit.

On a 2-player game, latches the 2nd coin relay.

Operates the reset motor, if there is a trip relay bank.

Energizes the lock relay.

May reset features units, if any.

(c) Functions of the reset relay:

Will energize only at the start of a game.

The main function of the reset relay is to reset the score drum units thru the score reset relay(s).

Operates the score motor.

On a 4-player game, in conjunction with the coin relay resets the player up unit and controls the coin unit step up or reset of the unit.

On a 2-player game, it controls the latch or trip of the 2nd coin relay.

While the reset relay is energized, it prevents the features relays and scoring relays from operating.

May reset features not reset by the coin relay.

(d) There may be other feature relays or units that are special features of that particular game.

(2) During the play of a game:

(a) Functions of the outhole relay:

Operates the score motor

Advances the ball count unit after a ball has been played and no extra ball has been earned, except in a 4-player game it will advance the player up unit until the last eligible player has played at which time it will advance the ball count unit and reset the player up unit.

Resets feature units, except hold-over features.

Completes circuit to operate the outhole kicker solenoid.

While energized, will drop out the tilt relay on all 2 and 4 player games, also adjustable on some one player games.

(b) Functions of the outhole relay on a 2 or 3 ball game:

The functions are the same as above, except this relay does not advance the ball count unit or the player up unit or drop out the tilt relay. Instead of these functions, the outhole relay controls the circuit to the 2nd or 3rd ball relay and the ball release relay when all balls are out of play.

(c) Functions of a 2nd or 3rd ball relay:

A 2nd ball relay is used on a 2 ball game.
This relay is energized when the outhole relay is energized and both balls are out of play.

This relay when energized indicates the end of the play for the player up on that ball.

A 3rd ball relay is used on a 3 ball game.
This relay is energized when the outhole relay is energized and all three balls are out of play.

This relay when energized indicates the end of the play for the player up on that ball.

When both the ball release relay and the 2nd or 3rd ball relay are energized, they complete the circuit to advance the player up unit or advance the ball count unit and reset the player up unit.

(d) Functions of ball release relay:

This relay is energized when both of the balls are out of play in a 2 ball game, or when all 3 balls are out of play on a 3 ball game.

When the outhole relay and the 2nd or 3rd ball relay are energized then the outhole relay drops out, the ball release relay is energized.

If the outhole relay is not energized, only the ball release relay will operate.

Advance the ball count unit or the player up unit if both the ball release relay and the 2nd or 3rd ball relay are energized.

Operates the score motor

Energizes the ball release solenoid thru the normally open #4 score motor cam switch.

(e) The ball count unit will advance only when the ball index relay is energized; if the extra ball relay is not energized.

On some 1-player games, the ball count unit is advanced at the start of the game and the unit is reset one position at a time at the end of each play. The unit will advance one position whenever an extra ball is earned up to and including 9 balls to play.

When the score glass reads "balls to play",the ball count unit resets one position at the end of each play.

When the score glass reads "ball in play", the ball count unit advances one position at the end of each play.

On a 4-player game, the ball count unit does not advance until the last eligible player has played. This is determined by the player up unit in conjunction with the coin unit.

(3) Completion of a game:

(a) The game over relay is tripped when the adjusted number of balls have been played thru the ball count unit disc. The game may be adjusted for either 3 balls per game or 5 balls per game not counting the extra balls scored.

(b) The game over relay is tripped when the power to the game is cut off even momentarily, thru the lock relay switch.

(c) On most 1 player games, if the game is tilted the game over relay is tripped. On some 1 player games, it is adjustable to trip the game over relay or stop the action of the ball in play.

(4) Functions of the 2nd and 3rd coin chute relays:

(a) The main function of these relays is to add credits to the credit unit for coin played, the number of credits is determined by the adjustments on the 3rd coin chute adjustment plug.

(b) These relays do not reset the game. To reset the game, it is necessary to press the credit button on the front door.

(c) These relays should operate the score motor.
If either relay is energized but the score motor does not operate check the following:

The score motor terminal plug should be plugged in.
The coin chute switch wire form should be in top position of curved slot.
Turn score motor cam manually, it may be jammed.
Check switch adjustment of relay which is energized, especially the switch with a red-yellow wire.

TROUBLE-SHOOTING HINTS

Coins Rejected:

1. (a) Visually check the coin lock-out coil on the front door. It should be energized with the armature flap touching the coil core. If not energized,check following:

(b) Checks for power supply to the game:
Check with a meter or test probe from yellow wire to black wire for 50 volts.

If no meter or test probe is available, press left flipper button. The display lites should lite.(Not on later models)

(c) Causes of power supply failure:
Power line "on-off" toggle switch may be turned "off" (switch is located on bottom of cabinet).

Power line fuse may be burned out or not making good contact with fuse holder. Unplug game before checking. (the fuse is located by the transformer, in early models).

Line cord may be broken.

Power failure to line cord.

50 volt fuse may be burned out or not making good contact with fuse holder. This fuse has red-white wire and black wire.

(d) Power supply is okay: and coin lock-out is not energized, check following:

Score motor terminal plug should be plugged in.

#1 score motor cam switch with yellow wire and gray-red wire should be making.

Cable connector from cabinet to mounting panel properly plugged.

Check for 50 volts at coin lock-out terminals.

The coin may be defective.

Coin lockout bar may be jammed or binding.

2. If coin lock-out is energized and the coins are rejected clean out the coin acceptor mechanism. There may be some foreign matter slowing down or deflecting the coin.

Score Motor

1. Score motor runs continuously at start of game, check following, in order listed below:

(a) If credit relay is energized, check adjustment of credit button switch and #7 score motor switch with brown-red wire and green yellow wire. Also check adjustment of credit relay switch with green-yellow wire and brown-red wire.

(b) If coin relay is energized, check adjustment of lst coin chute switch and #8 score motor switch with brown-red wire and blue-white wire. Also check adjustment of coin relay switch and credit relay switch with blue-white wire. Also check adjustment of coin relay switch and credit relay switch with blue-white wire and gray wire.
If 2nd coin chute adjustment plug is adjusted, for one play from 2nd coin chute, check adjustment of that switch.

(c) If 2nd or 3rd coin chute relay is energized, check the switch adjustment of the respective coin chute. The wire form that actuates the switch may have come out of the slot. It is best to remove the coin acceptor mechanism for better viewing. Also check the 3rd coin chute adjustment plug. If 2nd coin chute relay remains energized unplug the plug with a brown-white wire; if it is the 3rd coin chute relay, unplug the one with the orange-white wire. If this corrects the problem, check the score motor cam switch involved and the coin chute relay switch that locks in the relay. (the switch with a jumper wire to the relay coil).

(d) If the reset relay is energized, this relay is pulled in by the coin relay. Once energized it is held energized by all score drum units zero switches, as well as by #8 score motor cam switch with yellow wire and green-black wire. If any one of these switches does not open, the reset relay will remain energized. The top zero switch locks-in the reset relay. The switch below it, completes the circuit to pulse the solenoid until the unit reads "0".

2. Score motor runs continuously, during play of a game:
   (a) Check the adjustment of the #1 score motor cam switch with a yellow wire and red-yellow wire. This switch should open at index position of the score motor unit.

   (b) If there is a ball in the outhole and the ball does not kick out, check the outhole kicker circuit on the schematic. The pulse that operates the outhole kicker solenoid is generally on cam 7 or cam 4. Check adjustment of switches on these cams. It is also possible that the outhole kicker solenoid is defective.

3. Score motor does not run:
   (a) Check the score motor terminal lug. The wire may be unplugged.

   (b) If the 3rd coin chute relay is energized, generally there is something holding the 3rd coin chute switch in a down position. To check, remove the 3rd coin acceptor mechanism. On some games, it is also necessary to check the 2nd coin chute.

Game Over Relay

1. This relay is generally an interlock relay, which is operated by a trip coil and a latch coil, the trip coil is the assembly that releases the switch actuator, and the latch coil is the assembly that sets-up the switch actuator. On some games, the game over trip relay is located on the trip bank assembly.

2. The trip circuit is explained under heading introduction to servicing sub-heading completion of a game.

3. If the game over relay fails to trip:
   (a) When game is completed:
   Check adjustment of wiper fingers on ball count unit disc.

   Check the rivets on the ball count unit disc, they may be dirty, clean the disc using a mild abrasive. Check wiper tension, it should be about 1 ounce pressure, check the balls per game. See that it is in the proper position.

   The ball count unit should reset at the start of each game. On some 1 player games with score glass marked ball in play, the ball count unit will advance two steps for 3 balls per game, or four steps for 5 balls per game.

(b) If power is temporarily interrupted, check lock relay, it should be de-energized. Also check switch adjustment of normally closed lock relay switch with yellow wire and green-red wire.

(c) At the start of a game, the game over relay should trip, if the ball count unit had been advanced.

Check the ball count unit zero switch with yellow wire and gray-white wire. This switch should close when the ball count unit advances one position.

On a 4-player game, also check the zero switch on the player up unit with the same wire colors. This switch should close when the unit advances one position.

Credit Unit (also see under heading Step-up Units)

(1) This unit records the number of plays available with the credit button.

(2) Credits are increased (up to and including 25 credits) by:
(a) 2nd or 3rd coin chute relay when energized.
(b) When a game is adjusted to award a credit when a pre-adjusted score is registered.
(c) When number match is registered at the end of a game (when so adjusted).
(d) Special feature award (not on all games) is earned and adjusted to award a credit.

(3) Credit is deducted when the credit button is used to start a game or to make additional players eligible to play.

(a) Credit is not deducted when a coin is used to energize the coin relay.
(b) The credit button when pressed (with a credit shown) will energize the credit relay; which in turn will energize the coin relay.

The credit relay when energized must remain energized thru its own lock-in switch, in series with the normally closed #7 score motor cam switch, in order to deduct a credit.

Score Drum Units

(1) Reset at start of a game:
(a) These units are reset by pulses from the score reset relay(s) that step the units to zero positions. When a unit reads "0" the zero switch on the unit should open (2nd switch from top) to stop the unit from advancing.

(b) When the reset relay is energized, it will remain energized by its own lock-in switch, in series with the zero switches of all the score drum units.

If any one of the zero switches (top switch) is closed, the reset relay will remain energized. The reset relay is also held energized by the #8 score motor with yellow wire and green-black wire.

(c) The score reset relay (s) is fed by the same circuit that holds the reset relay energized the pulses come from #2 and/or #11 score motor switches.

(2) Advance during play of game

(a) one units score is a dummy reel and does not advance.

(b) 10-90,100-900 and 1000-9000 score units are advanced by their respective 10 point, 100 point and 1000 point relays.

(c) 10,000-90,000 units are advanced by the 1000 point relay switch in series with the 9th position switch on the 1000-9000 unit (bottom switch). The 9th position switch should close when the units reads "9".

(d) When the 10-90 score drum reads "9" and 10 points are scored, the 10 point relay is energized which will advance the 10-90 score drum unit to zero and at the same time will energize the 100 point relay thru the 9th position switch (bottom switch) on the 10-90 score drum unit.

(e) Scores from 100-900 score drum unit is transferred to the 1000-9000 score drum unit in the same manner as described under (d).

(f) In a 2 player game, the above circuit also involves the ball count unit disc to separate the 9th position switches of 1st and 2nd players.

(g) In a 4 player game, the above circuit involves the player up unit disc to separate the 9th position switches of various players.

(h) There is an end-of-stroke switch on 10-90, 100-900 and 1000-9000 score drum units (on bottom of units), which holds the respective 10,000 or 1000 point relay energized until the respective unit drive arm has engaged the next tooth on the ratchet. The unit is advanced by a spring when the solenoid is de-energized. The end-of-stroke switch must open when the drive arm has 1/32" travel to engage the next tooth of the ratchet.

Thumper Bumper

If the thumper bumper skirt (plastic ring with post that goes thru the hole in the playfield) gets stuck, it can be due to two things:

(a) The post on the skirt is not centered in the cup of the switch blade. To correct this, the switch mounting bracket may have to be moved.

(b) There may be too much switch tension on the tip of the skirt post.

(c) Clean out the cup on the switch blade and apply a very small amount of coin machine grease in the cup. (on metal cup only).

Post

There are two models of the post assemblies:
(a) Old model - has only a solenoid.

(b) New model has a solenoid and a latch coil. On the old model, the solenoid should be de-energized at the end of a game.

On the new model, the solenoid should de-energize when the post is latched in down position.

If it remains energized, check the adjustment of the end-of-stroke switches. The switches should be adjusted in the latched position. Don't hold down plunger while adjusting switches. The over-travel of the plunger in relation to latch position is about 1/32". This is adjustable by moving the latch coil assembly.

Game does not score

(1) Check 50 volt fuse.
(2) Check cable plugs.
(3) Check adjustment of following normally closed switches:

Game over relay switch with black wire and yellow-black wire.
Reset relay switch with yellow-black wire and red-white wire.
Tilt relay switch with red-white wire and red wire.

(4) Check 10 point, 100 point and 1000 point relays to see if any of them are energized. Check following if a relay is locked in:

Playfield panel switches, that energize the relay. Switches should be open. Check lug end of switch, see that there is no strand of wire shorting switch, or a piece of conducting material.

(5) Check game over and tilt relays - one or both may be tripped.

Relays

(1) Cleaning Contacts:
Only use burnishing tool. Don't use a contact file, the contacts are silver.

(2) Switch adjustment:
Adjustments should be made with a stroking action. Sharp bends fracture the blade.

(3) Buzzing relays:
Buzzing is generally caused by the armature not being able to properly seat on the coil core.

Causes of buzzing:
Too much back tension on switch blades.
Too low voltage to the transformer.
Burr or foreign substance on the coil core relay frame bent out of shape.
Armature bent.

Step-Up Units

Step up unit solenoids do not advance the units, they pull the drive arm to engate the next tooth on the ratchet. When the solenoid is de-energized, the spring on the drive arm advances the unit to the next position.

(1) Sluggish units:
To check, non-resetting units:
Raise the drive (step up) pawl and index pawl from the ratchet (see parts catalog,page 113).
Rotate wiper assembly, it should turn freely.

To check, resetting units:
Manually reset unit, then rotate wiper assembly; it should turn freely.

To check, escapement reset units:
(see parts catalog, page 146). Hold down reset plunger and raise escapement pawl away from ratchet.
Rotate wiper assembly or on replay counter unit, rotate the drum they should turn freely.

(2) Causes of Sluggishness:
Units with disc and wiper assembly. Disc may be dirty, residue of old grease or oil.

Resetting unit with a zero switch should be able to reset when unit has advanced only one step.

Too much tension of zero switch against ratchet pin may hold ratchet from a complete reset.

Resetting unit with a limit switch when manually turned past the limit position may hang up on the limit switch, thus prevents unit from resetting to zero position.

ELECTRONIC FLIPPERS GAMES

The procedures contained herein are written for use by the Service Center that cannot justify the purchase of the fully automated module test equipment available from Bally. The procedures allow fault localization, analysis and repair in an organized, direct manner. It is necessary to read, understand, and follow the procedure step-by-step until a cause for the problem is determined and the remedy for the problem, as given in the procedure, is put into effect. The few minutes spent to read and understand the procedure will prevent problems and save time.

Repair of each of the five (six, Lost World and Later) types of electronic modules used in the games is accomplished by using a known good game as a test-bed. (See Figures I & II, Pages 4 and 5). The procedures, when used with a set of module schematics, facilitate fault localization to the defective component. Repair is accomplished by standard electronic module repair practices. A stock of replacement components is necessary. The specific memory (ROM/PROM) chips used for each different game must also be stocked. An AID Kit is required by the procedures. The modules AID mate with J5 on the MPU module. The Kit is available from the Bally Service Department. Order AID, Bally Kit #485-1. No other special tools or equipment are required.

The repair procedures take advantage of the two test routines designed into the game. These are the MPU Self-Test and the Self-Diagnostic Test.

A. The MPU Self-Test occurs on power-up. The MPU module examines itself for proper operation. The MPU goes thru a sequence where it does a check-sum on its read-only memory bank, exercises its read-write memory bank, exercises each peripheral input/output port, examines its inputs for the presence of line voltage zero crossings, and for the presence of display interrupts. If all is proper, the MPU module flashes the LED seven times and announces play-readiness with the game-up tune. If, at any point in the test, performance standards are not met, the test is stopped. The game will not play until repairs are made. Counting the number of flashes that occur on power-up is used for fault localization on the MPU module.

   In a known "good game', this test is a measure of the MPU modules' ability to perform. In a defective game, the test results can be misleading if certain output lines are shorted to ground. It is necessary for purposes of the test procedures herein that the game used as a test-bed is known to be good.

B. The Self-Diagnostic Test is a routine that causes a known-good MPU module to 'exercise' each of the other electronic modules. The symptoms that arise when a defective module is tested are listed in each of the module diagnostic tables as a means to fault localization to the defective component. Different portions of the test are associated with each of the four types of modules. A flow chart for

the complete test is given in Figure III, Page 7. The chart illustrates the SEQUENCE of the Self-Diagnostic Test. Instructions for entering into the appropriate portion of the test are given in the figure. The page numbers shown in the blocks are not applicable for use with this part (II) of this manual. See Figure 1, Page 4 for location of Self-Test button on door.

C. The AID Kit, Bally Kit #485-1 extends the usefullness of the Self-Diagnostic Test to locate defective components. The AID modules are plugged into J5 on the MPU module before turning the power on.

AID1 is entered from the Self-Diagnostic Test by pressing S33 on the MPU Module. AID1 permits on-module signal continuity and functional checks under digital operating conditions. The test probe is clipped to TP1 and is placed in the circuit under test as detailed in the module diagnostic tables. The LED on the MPU module lights if operation in the circuit is proper. The tables detail the corrective action to be taken if the LED does not light.

When a properly operating game is in the AID1 mode, all switched incandescent display lamps and the digital display panels on the Display Driver Module are off. A humming noise may be heard. It is normal for the sound to stop as the probe is placed in various circuits in the game.

IMPORTANT: The only exit from AID1 to the normal operating game routines is by way of the ON-OFF switch. Simply, position the toggle to "OFF" and then again to "ON". Normal games routines or the Self-Diagnostic Test routine are then available.

AID2A is used during trouble shooting of the MPU module. It is plugged into J5 before power is turned ON. It is used to detect bus line faults on the address, date and Read/ Write lines as discussed in the MPU module diagnostic tables.

SERVICE HINTS, GENERAL:

A. VISUAL INSPECTION prior to servicing can often minimize service time requirements. Inspect modules for overheated components, swollen capacitors and physically damaged parts.

B. Schematics and parts lists are essential to module servicing. Component reference designations made in the diagnostic procedures are the same as those used on the schematics and in the parts lists. Solenoid and switch assembly reference numbers are given in the tables stapled in the backbox.

C. No special tools are required for servicing. A 20,000 Ohm/Volt meter, Simpson Model 260 or equivalent, jumper-leads, and hand tools (including a grounded element soldering iron) are considered standard servicing tools.

D. Read all of the Module Symptoms in the Module Diagnostic Table before attempting to make a diagnosis. Study the symptoms presented by the defective module. Follow the procedure associated with the most applicable symptom description in the Module Diagnostic Table.

E. Make a record of all bookkeeping functions before using AID1. When using AID1, a noise pulse induced on the line under test can occasionally cause the MPU to 'jump the track'. If this happens, turn off the game, and reenter AID1 through the Self-Test routine.

F. The MOS and CMOS devices used in the modules are susceptible to damage from static discharge. Ground yourself, your workbench and the module under repair. Touching the ground braid in the game or the conduit in the work area frequently is a good practice. Use a grounded element soldering iron to make repairs.

G. Clip out defective transistors and integrated circuits not in sockets to facilitate removal and prevent damage to the printed circuit boards.

H. Use care not to flex printed circuit boards. Damage to foil or plated through holes can result from careless handling.

MPU MODULE A4

An MPU Self-Test occurs on power-up. Positioning the ON-OFF switch on the game to the "ON" position initiates the test. Successful completion of the test is indicated by seven flashes of the LED (Light Emitting Diode) on the module. Figure A-4-1 directs the serviceman to the proper entrance point in the diagnostic table for less than seven flashes. It is necessary to read, understand, and follow the procedure step-by-step until a cause for the problem is determined and the remedy for the problem, as given in the procedure, is put into effect. The few minutes spent to read and understand the procedure will prevent problems and save time later.

During certain steps in the procedure, it is necessary to determine the condition of the address, data and read/write lines (bus.). Each line is examined for the following faults: Inputs 'stuck' high or low (shorted to ground), shorts to adjacent leads and continuity between devices on the bus. The procedure also examines the status (good or failed) of several decoding integrated circuit inverters, buffers and gates on the A_9-A_{12} address lines. To accomplish this testing with the use of a voltmeter, bus lead connection points are provided by means of J5. Continuity between devices on the bus is ascertained by the use of Table A4-1 (or the schematic) and a voltmeter.

An AID2A module, used to locate bus line faults on MPU address, data and read/write lines is included in the AID Kit, Part #485-1, available from Bally, or may be made by the user. (Fig. A4-2).

The AID2A module is connected before the game is turned on. It is used to ground the HALT line. When the game is turned on, the address, data and read/write bus lines all go to a high impedance state and the VMA line goes low. In this state, the clip lead on the resistor COMmon can be used to make all bus lines high (clip to +5V) or low (clip to GND). When high, continuity to the pins of any device on the bus can be read with a voltmeter. Lines ' stuck' low due to a failed device become 'visible' to the voltmeter. When the clip is connected to ground, lines 'stuck' high due to a failed device also become 'visible'.

The GND is used to find adjacent lead shorts. The resistor COMmon lead is connected to +5V. The GND lead is connected to each resistor, one position at a time. With the lead on a given resistor, a short to an adjacent line will result in a reading of Zero on the adjacent line. All other lines will read approximately +5VDC.

Visual inspection can usually locate solder-splash adjacent line shorts. Removal of socketed integrated circuits one at a time locates failed devices on the line.

The MPU Self-Test is supplemented by the PIA 'B' Port procedure given in A4-IX. This procedure MUST be performed each time an MPU Module is tested. See Figure A4-1. Successful completion of the MPU Self-Test does not guarantee that the MPU module is good. Successful completion of both the MPU Self-Test and the PIA 'B' Port procedure, however, does mean that the MPU module is good. The AID1 module is used in this procedure.

SERVICE HINTS

A. Voltages shown on schematic are typical operating voltages after the power-up MPU Self-Test is complete. They are dynamic in nature and represent the voltmeters response to a digital information flow at a particular point in the game program. Voltage at the output of a failed device will differ from the voltages shown. The voltages shown on the schematic are, therefore, a useful trouble shooting aid and must be used for reference.

B. The trouble shooting procedures are slanted towards ease of maintenance. If either of two devices could be the cause of malfunction, and one is soldered into the circuit and the other is inserted in a socket, the procedure will advise substitution of the socketed device first. See Caution.

C. When substitution of a socket mounted device with a known-good replacement does not solve the problem, the device removed should be set aside and retested later in a known-good module. See Caution. If the device tests good, it should be returned to stock. If bad, it is recommended that several leads be cut off before discarding to mark the device as defective.

D. A part number is on each ROM (or PROM), U1-U6 incl., used in the game. Each ROM (or PROM) can only be replaced with a ROM (or PROM) with an identical part number. Failure to do so will cause improper game operation.

E. It is assumed that the repairman will turn off the power before using an ohmmeter, removing or inserting an integrated circuit or initiating repairs.

CAUTION: MOS and CMOS integrated circuits are damaged by static charges. It is good practice to ground yourself to the braid in the game before removing or inserting an integrated circuit, to conduit-ground your work surface (bench) and tools. A grounded element soldering iron is also necessary.

LAMP DRIVER MODULE

The Lamp Driver module part of the Self-Test energizes each of the sixty lamp driver output circuits on the module. The game used as a test bed, however, may not have a lamp assigned to each of the output circuits. If it does not, the following procedure can be followed.

A. Use the Lamp Driver module part of the Self-Test. If faults are found, use the symptoms to select a repair procedure. Restore the module to operating condition by following the procedure.

B Use the test bed game schematic. Make a list of the Lamp Driver circuits that did not have lamp loads.

C. The LED on the MPU module is used as a substitute for a lamp load. If the circuit under test is good, th LED will flash on and off just as the lamps in the test bed game do. Access to the anode of the first Lamp Driver SCR on the list is available at J1, J2 or J3. Refer to the Lamp Driver module schematic. Insert a 3/4" piece of solid wire (ex: a resistor lead clipping) into the connector contact position to be tested. Connect a test lead from TP6 on the MPU module to the piece of wire.

D. Repeat A.

E. Repeat C and A for each of the remaining Lamp Driver circuits on the list.* Return the module to stock or repair, as required.

Lamp Bank Extender modules can be tested in the test bed game.

If the game has provision for a Lamp Bank Extender, insert the module in its proper place and conduct the Lamp Drive Module part of the Self-Test. The procedure above must be followed to test unused outputs.

If the game does not have provision for a Lamp Bank Extender module, insert it in the Lamp Driver position. Connect J4, cable harness to J4 on the module, J2 to J2. Testing is the same as for the game with provision for the module. Unused outputs can also be tested. Lamp assignments are given on the test bed game Lamp Driver module schematic.

DISPLAY DRIVER MODULE

CAUTION

Before inserting module in game, probe the 190 VDC circuit to ground, TP2 to TP3, with an ohmmeter. Clear shorts, if present, before inserting module in game. Shorts on the 190 VDC supply line can cause failure of the Solenoid Driver/Voltage Regulator module, A3.

High voltages are present in the display panel driver circuits (+190 VDC) on this module. Exercise due caution when servicing.

Careless or accidental probe slips that short the +190 VDC circuit to ground or to the +5 VDC or logic circuits can cause failure of the Solenoid Driver/Voltage Regulator module (A3) and MPU Module (A4). It is recommended that a standard or needle tipped probe similar to the AIR probe be used to perform voltage checks. Alligator clip leads are to be avoided unless special precautions are taken.

SOLENOID DRIVER/VOLTAGE REGULATOR

High voltages are present in the +190 VDC regulator circuit on the module. Exercise due caution when servicing.

Damage can result to the MPU module due to improper operation in the +5 VDC regulator circuit. Disconnect MPU module connector J4 before turning on power to test Solenoid Driver/ Voltage Regulator module. If voltage at TP1 is correct (+5 ± .25 VDC), connector on MPU module may be connected. If voltage at TP1 is incorrect, leave MPU module connector off until proper operation is attained.

The Solenoid Driver module part of the Self-Test energizes each of the nineteen solenoid driver output circuits on the module. The game used as a test bed, however, may not have a solenoid assigned to each of the output circuits. If it does not, the following procedure can be followed:

A. Use the Solenoid Driver module part of the Self-Test. If faults are found, use the symptoms to select a repair procedure. Restore the module to operating condition by following the procedure.

B. Use the test bed game schematic. Make a list of the Solenoid Driver circuits that did not have Solenoid loads.

C. The LED on the MPU module is used as a substitute for a solenoid load. If the circuit under test is good, the LED can be made to flash on and off in the test bed game. Access to the collector of the first solenoid driver transistor on the list is available at J1, J2, J3, or J5. Refer to the Solenoid Driver module schematic. Insert a 3/4" piece of solid wire (ex: a resistor lead clipping) into the connector contact position to be tested. Connect a test lead from TP6 on the MPU module to the piece of wire.

D. Repeat A.

E. Repeat C and A for each of the remaining Solenoid Driver circuits on the list. Return the module to stock or repair, as required.

Solenoid Bank Extender modules can be tested in the test bed game.

If the game has provision for a Solenoid Bank Extender insert the module in its proper place and conduct the Solenoid Driver module part of the Self-Test. The procedure above must be followed to test unused outputs. If the Game does not have provision for a Solenoid Bank Extender module, insert it in the Solenoid Driver position. Connect J4, cable harness to J4 on the module, J2 to J2. Testing is the same as for the game with provision for the module. Unused outputs are also to be tested. Solenoid assignments are given on the test bed game Solenoid Driver module schematic.

SOUND DRIVER MODULE

Functionally, the Sound module is divided into six circuit areas, as follows:

1. Power Supply (Q1 and associated components).
2. Tone Date Processor (U2, P/O U1 and U3).
3. Programmable Frequency Generator (U13, U1C, U4, U5 and U11).
4. Tone Trigger Generator (U7, and associated circuitry).
5. Voltage Controlled Alternator (U8).
6. Audio Amplifier (U9 and U10).

The following outlines a simplified test sequence to aid in quick localization of a fault to one of these circuit areas. Once the area of the fault has been determined, use must be made of the referenced sections for a more detailed analysis.

Unless stated otherwise, all measurements are made with respect to TP2, the ground line of the Sound module.

1. POWER SUPPLY CHECK

Measure +5 ± 0.25 VDC at TP1 and +12.5 ± 1.3 VDC at TP3. If incorrect, go to Section I.

2. FREQUENCY GENERATOR CHECK

Measure + 0.8 VDC at junction of R3 and R5. If incorrect, go to Section II.

3. AUDIO AMPLIFIER CHECK

Measure +2 VDC (approx.) at U9, pin 2. Observe that a ticking sound is produced each time U9, pin 2 is touched with meter test lead. If incorrect, go to Section III.

4. TONE TRIGGER GENERATOR CHECK

With the game in play mode, activate any playfield switch that will result in momentary solenoid (slingshot, etc.) activity. On the Sound module, connect a jumper from TP1 (+5V) to U2, pin 5 (the junction of R24 and R28, see schematic). No sound should be heard, unless a playfield switch is activated.

If sound is heard with the jumper installed, refer to Sections V and II (in that order).

Activate a playfield switch. If sound is heard with jumper in place, but not without it, go to Section IV.

5. VOLTAGE CONTROLLED ATTENUATOR CHECK

Temporarily place a short between pins 1 and 2 of U8 on the Sound module and activate a playfield switch.

If sound is heard with the short installed, but not without it, refer to Section III.

If sound is not heard with the short in place, refer to Sections V and II (in that order).

COMPUTER SOUND MODULE

To select a sound, the Sound module decodes the address signals received from the MPU module via the five address lines A, B, C D and E (J1, pins 1, 2, 3, 4 and 12). The address is read and the sound is started only if a sound interrupt is also received from the MPU. This interrupt is caused by the low to high transition of the solenoid bank select signal (J1, pin 8).

The troubleshooting procedure, outlined herein, assumes that the MPU module is functional and that the above signals are generated. In general, since four of the address lines (A, B. C and D) and the solenoid bank select are shared with the Solenoid Driver module A3, faulty operation of these signals may also result in solenoid drive problems. In this case, the Sound module should be disconnected and if the fault persists, reference should be

made to the MPU and/or Solenoid Driver Troubleshooting Procedures. If the fault clears with the Sound module disconnected, the cause of the address or solenoid bank select signal degeneration should be determined and corrected at the Sound module. If that signal continuity exists between MPU and Sound module connectors. For a more complete test, AID may be used. Also, SW1 test switch on the Sound module may be used to start a test sound independent of MPU signals. This feature permits an overall check of the Sound module operation and may be used to simulate playfield switch activity. (NOTE: Early sound program versions do not provide this capability.)

TEST AND MEASUREMENT TECHNIQUES

Unless otherwise specified, all voltage measurements indicated on the schematic or called for in the troubleshooting procedure are made with reference to the ground test point TP3. Use of a Simpson 250 VOM, or equivalent, is assumed.

1. AC AND AUDIO VOLTAGE MEASUREMENTS:

   AC and audio voltage measurements require the addition of a 0.1 ufd (25WVDC min.) capacitor in series with the test lead connected to the signal (+) terminal of the voltmeter. This is necessary to block any DC voltage which may be present. Failure to observe this technique will result in misleading AC readings when using Simpson 250 VOM. (Other voltmeter models may have a built-in DC blocking capacitor or provide a special terminal for measuring AC signals in presence of DC. Reference should be made to manufacturer's recommendations, if use of a voltmeter other than Simpson 250 is necessary.)

2. SOUND-IN-PROGRESS:

   Some measurements indicated on the schematic, or called for in the test procedure, are to be made with or without sound in progress. When sound is heard, the term is self-explanatory. When, due to a malfunction, sound is not heard, "with sound" or "sound-in-progress" measurements should be performed under test conditions where a sound would normally be heard. (In practice there are several ways to achieve this. The game may be brought up to play and a play field switch, that should produce a sound, activated just before the measurement is to be taken. If the sound options switch is set such that no background sound is produced, both the "with" and "without" sound measurements can be readily obtained in this way. Another way is to put the game in sound self-test mode, in which case the sound interrupt triggering a test sound will occur automatically). Similarly, measurements with no sound should be made under test conditions where no sound (including background) would normally be produced.