

ADVENTURES *in* ELECTRONICS



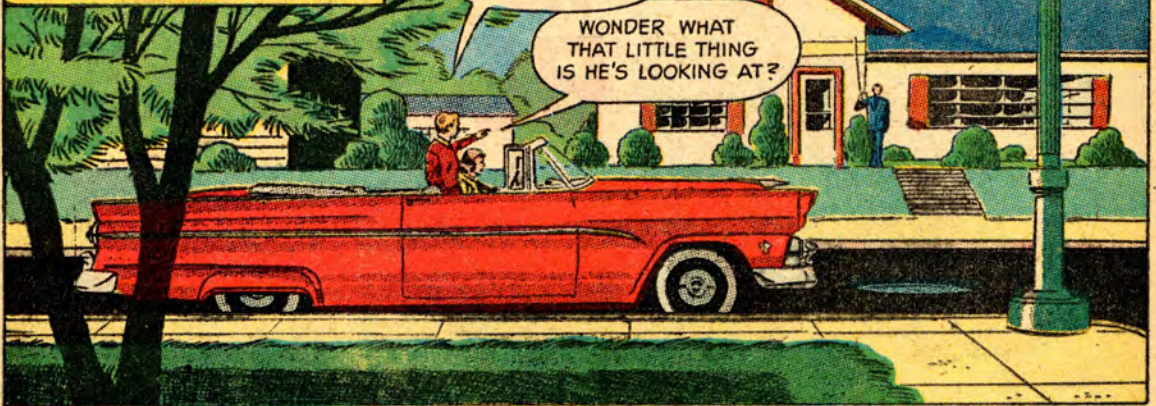
ADVENTURES IN
SCIENCE SERIES

GENERAL  ELECTRIC

ED POWERS HAS PROMISED A SPECIAL SIGHT-SEEING TRIP TO YOUNG BROTHER JOHNNY AND HIS FRIEND JANE -- BOTH EAGER TO GET UNDER WAY...

WHERE IS ED? HE SAID HE'D BE RIGHT OU-- OH, THERE HE IS!

WONDER WHAT THAT LITTLE THING IS HE'S LOOKING AT?



HELLO, JANE-- JOHNNY. BE WITH YOU IN A MINUTE...

THAT'S ED'S VOICE!-- BUT HOW?-- WHERE?--

THIS IS A REAL RADIO- BROADCAST, YOU TWO -- AND IT'S A VERY SPECIAL ONE.

--BEING MADE BY ME THROUGH THE MIDGET EXPERIMENTAL TRANSMITTER YOU SEE IN MY HAND!



IT'S COMING FROM THE CAR RADIO, JOHNNY! MUST BE A TRICK OF SOME KIND!

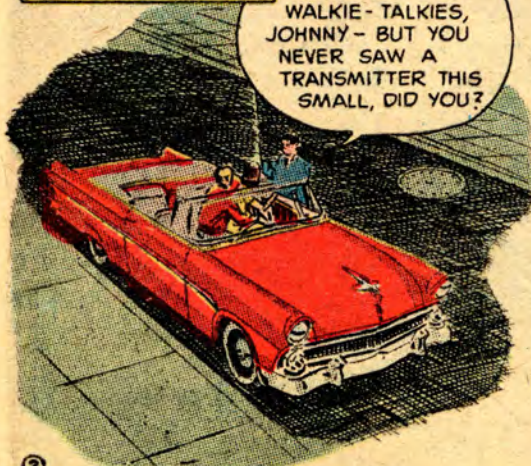


AND AS ED JOINS THE ASTONISHED PAIR...

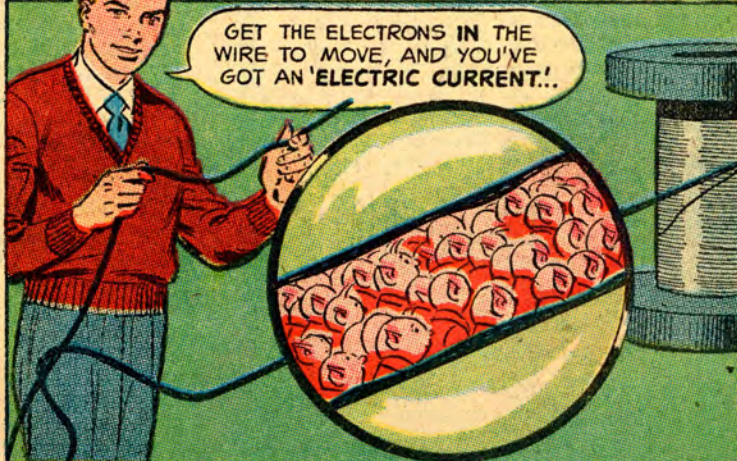
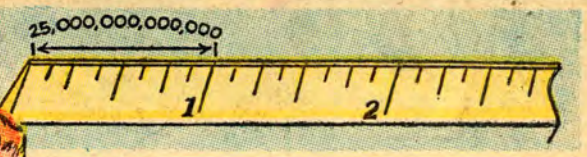
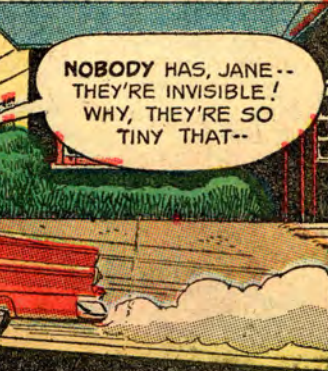
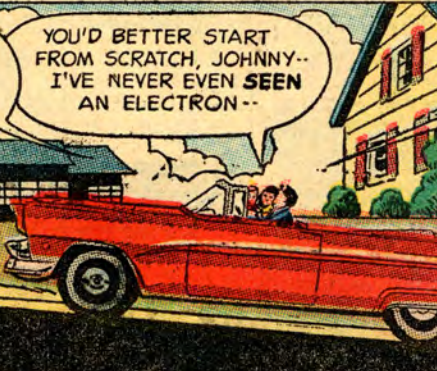
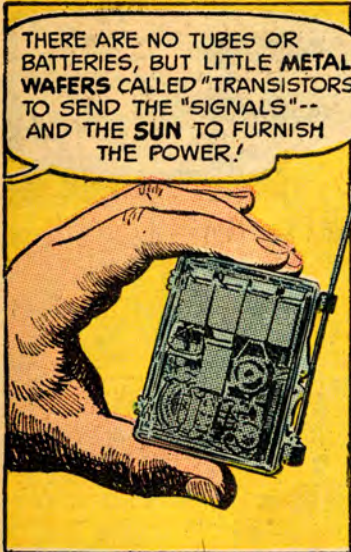
I KNOW YOU'RE FAMILIAR WITH WALKIE- TALKIES, JOHNNY - BUT YOU NEVER SAW A TRANSMITTER THIS SMALL, DID YOU?

LOOK AT THAT!-- THE WHOLE THING IS NO BIGGER THAN A PACKAGE OF CIGARETTES!

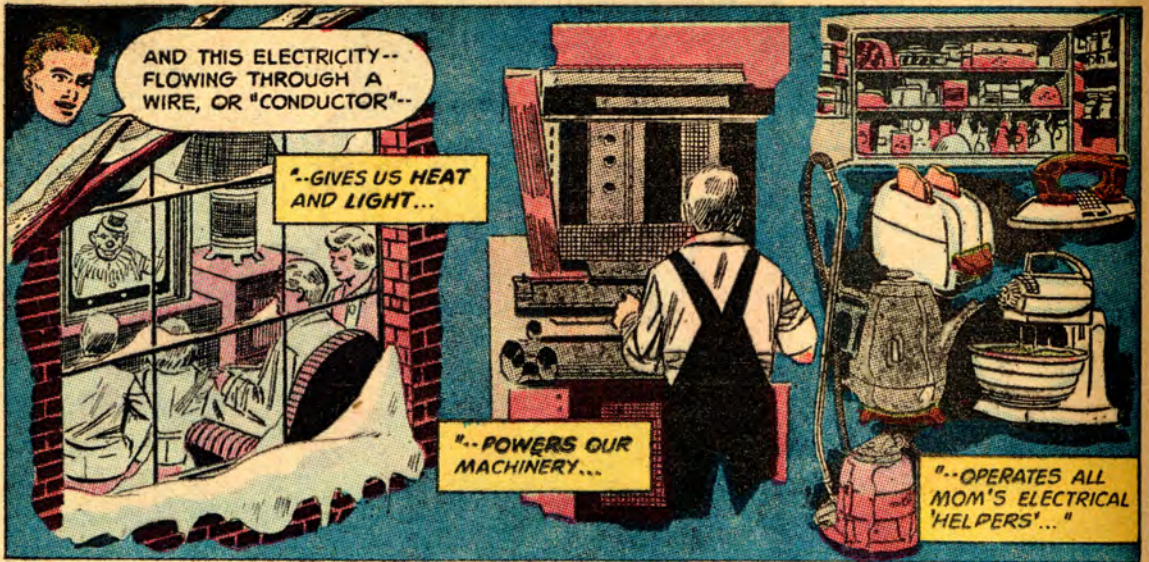
I DIDN'T KNOW TUBES AND BATTERIES COULD BE MADE THAT SMALL...



THAT'S THE REMARKABLE THING ABOUT THIS UNIT, JOHNNY--



"-- WHICH IS NOTHING MORE THAN A STREAM OF MILLIONS OF ELECTRONS 'PUSHING'-- IN A CONTINUOUS PATH, OR CIRCUIT!"

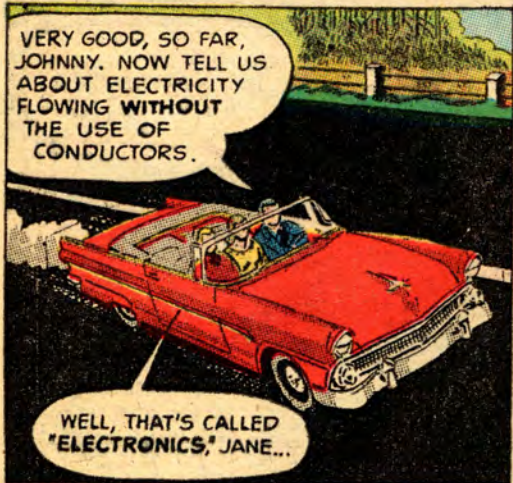


AND THIS ELECTRICITY--
FLOWING THROUGH A
WIRE, OR "CONDUCTOR"--

"--GIVES US HEAT
AND LIGHT..."

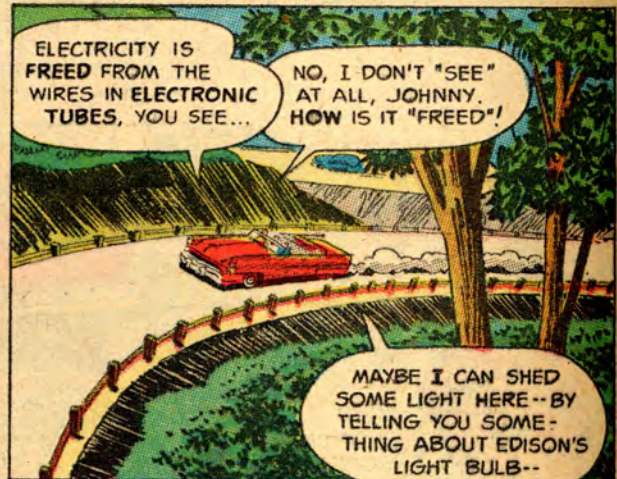
"-- POWERS OUR
MACHINERY..."

"--OPERATES ALL
MOM'S ELECTRICAL
'HELPERS'..."



VERY GOOD, SO FAR,
JOHNNY. NOW TELL US
ABOUT ELECTRICITY
FLOWING WITHOUT
THE USE OF
CONDUCTORS.

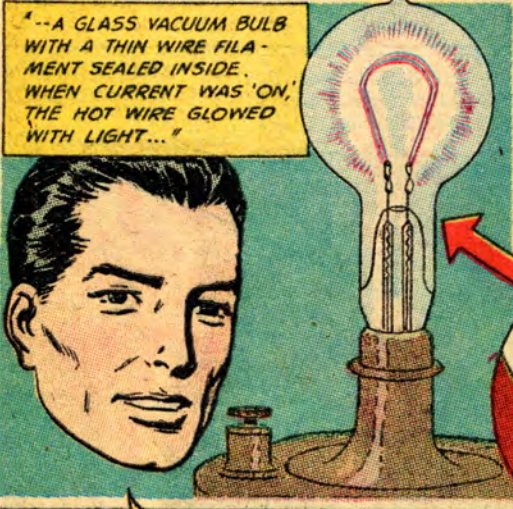
WELL, THAT'S CALLED
"ELECTRONICS," JANE...



ELECTRICITY IS
FREED FROM THE
WIRES IN ELECTRONIC
TUBES, YOU SEE...

NO, I DON'T "SEE"
AT ALL, JOHNNY.
HOW IS IT "FREED"!

MAYBE I CAN SHED
SOME LIGHT HERE--BY
TELLING YOU SOME-
THING ABOUT EDISON'S
LIGHT BULB--



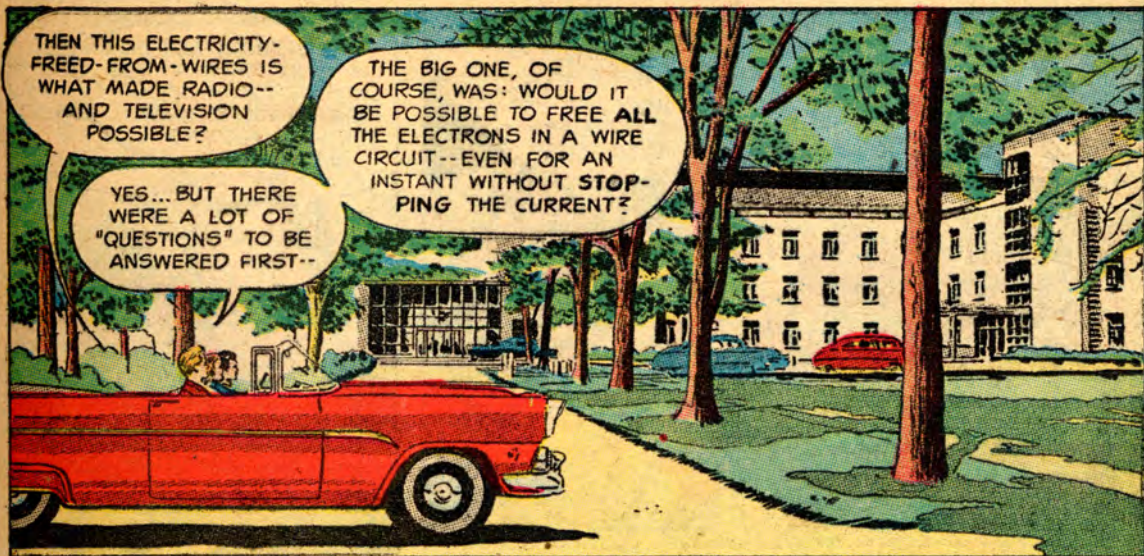
"--A GLASS VACUUM BULB
WITH A THIN WIRE FILA-
MENT SEALED INSIDE.
WHEN CURRENT WAS 'ON,'
THE HOT WIRE GLOWED
WITH LIGHT..."

"ALTHOUGH MOST
ELECTRONS PASSED
THROUGH THE WIRE,
A FEW OF THEM
WERE 'BOILED OFF'
INTO THE VACUUM,
PRODUCING A BLuish
GLOW IN THE SPACE
AROUND THE BASE
OF THE FILAMENT."

THIS MEANT THAT SOME ELECTRONS
HAD BEEN FREED FROM THE WIRE CIRCUIT!



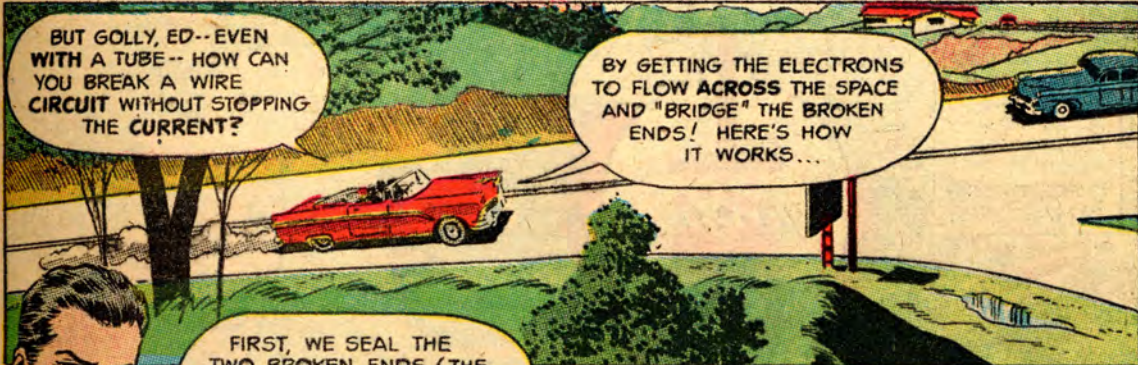
AND THIS DISCOVERY, CALLED
THE "EDISON EFFECT," SHOWED
US THE WAY TO THE VACUUM-
TUBE--AND TODAY'S WONDER-
LAND OF ELECTRONICS.



THEN THIS ELECTRICITY-FREED-FROM-WIRES IS WHAT MADE RADIO-- AND TELEVISION POSSIBLE?

THE BIG ONE, OF COURSE, WAS: WOULD IT BE POSSIBLE TO FREE ALL THE ELECTRONS IN A WIRE CIRCUIT--EVEN FOR AN INSTANT WITHOUT STOPPING THE CURRENT?

YES... BUT THERE WERE A LOT OF "QUESTIONS" TO BE ANSWERED FIRST--



BUT GOLLY, ED-- EVEN WITH A TUBE-- HOW CAN YOU BREAK A WIRE CIRCUIT WITHOUT STOPPING THE CURRENT?

BY GETTING THE ELECTRONS TO FLOW ACROSS THE SPACE AND "BRIDGE" THE BROKEN ENDS! HERE'S HOW IT WORKS...



FIRST, WE SEAL THE TWO BROKEN ENDS (THE "CATHODE" AND THE "ANODE") IN A VACUUM TUBE...



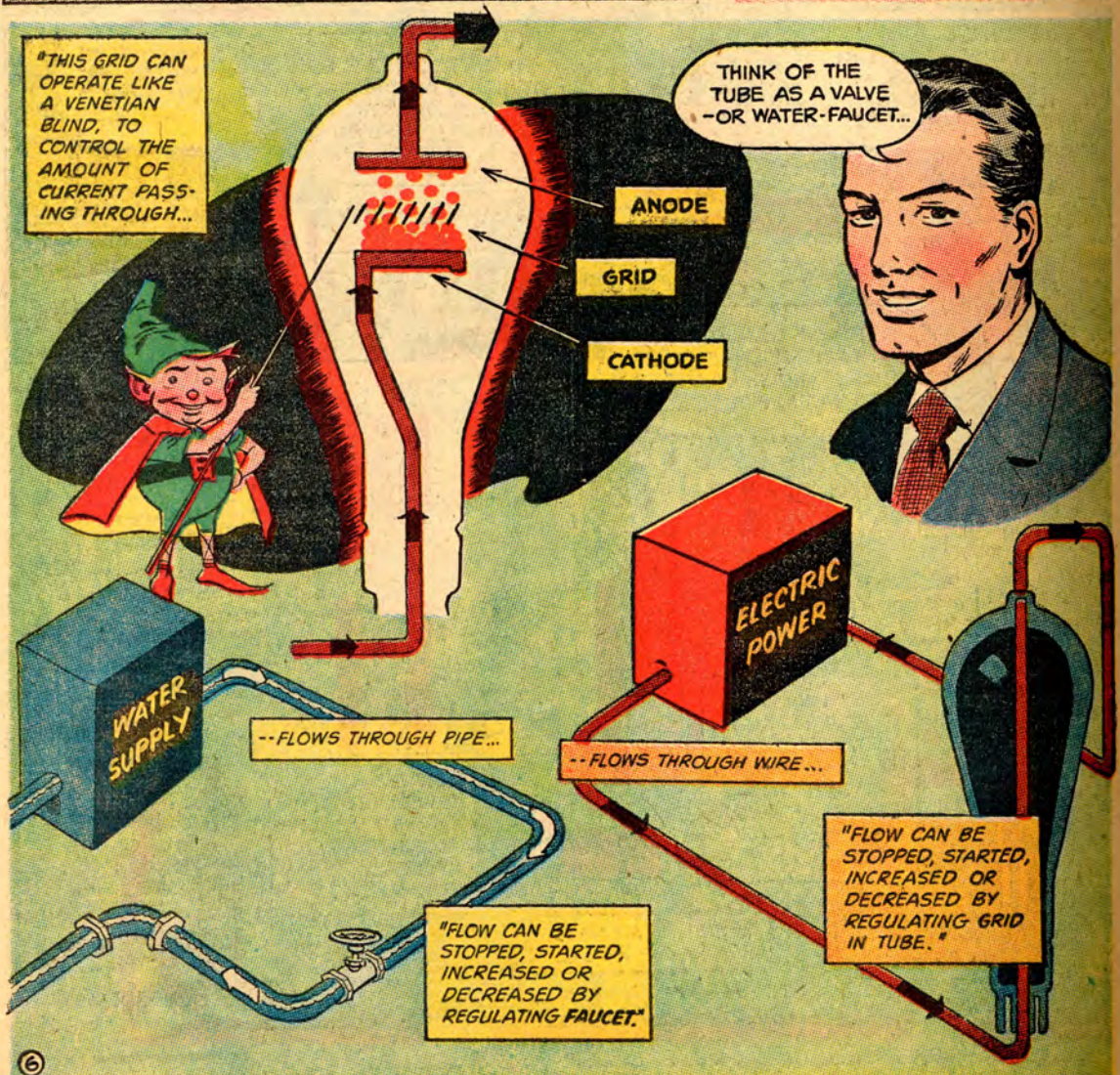
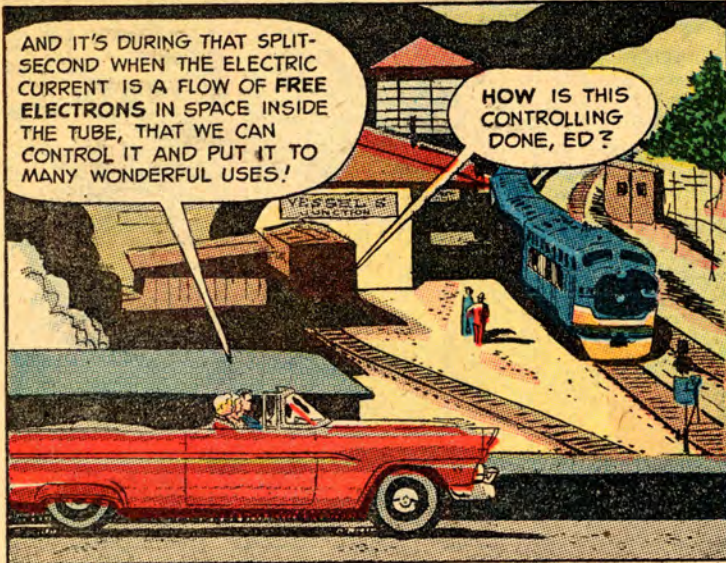
"THEN WE MUST FREE AND PUSH THE ELECTRONS OFF THE CATHODE END... AND WE DO THIS BY 'BOILING' THEM OFF WITH HEAT..."

"NOW THE ANODE TAKES OVER AND-- LIKE A MAGNET-- PULLS THE FREED ELECTRONS TOWARD IT."

"...JUST AS STEAM IS BOILED OFF WATER..."

"OF COURSE, THERE ARE MANY, MANY KINDS OF ELECTRONIC TUBES... BUT THIS SIMPLE ONE EXPLAINS HOW IT'S POSSIBLE TO SEND AN ELECTRIC CURRENT THROUGH SPACE!"





AND JUST WHAT HAVE ALL THESE "CATHODES" AND "ANODES" AND "GRIDS" GOT TO DO WITH TELEVISION?

YOU'LL SEE FOR YOURSELF IN A FEW MINUTES, JANE... THERE'S ELECTRONICS PARK UP AHEAD...

"THIS IS THE WORLD'S CENTER OF ELECTRONICS -- GENERAL ELECTRIC'S HEADQUARTERS FOR ELECTRONIC RESEARCH, ENGINEERING AND MANUFACTURING..."



SOON, AS THE SIGHT-SEEING GETS UNDER WAY...

AND THERE'S WHAT A TELEVISION CAMERA'S "INSIDES" LOOK LIKE...

BOY! AND YOU'RE GOING TO TRY TO TELL US HOW THAT WORKS?!

WELL, I'LL TRY TO GIVE YOU A SIMPLE IDEA, ANYWAY! LET'S GO BACK TO OUR CATHODE FOR A MINUTE. YOU SEE...

...JUST AS THE CATHODE GIVES OFF FREE ELECTRONS WHEN HEATED...



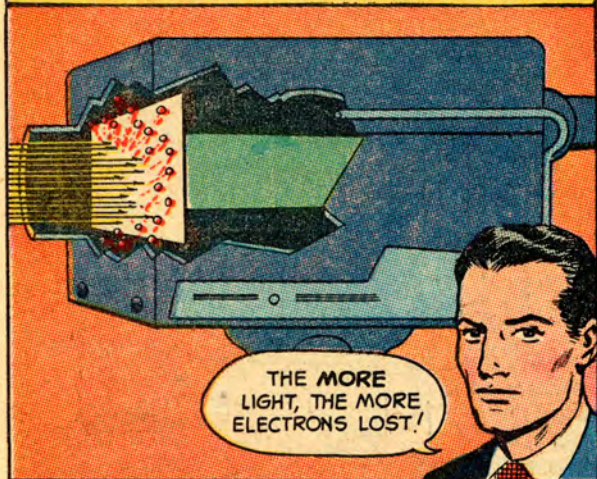
LIGHT BEAMS

...CERTAIN METALS ALSO RELEASE ELECTRONS -- WHEN EXPOSED TO LIGHT!

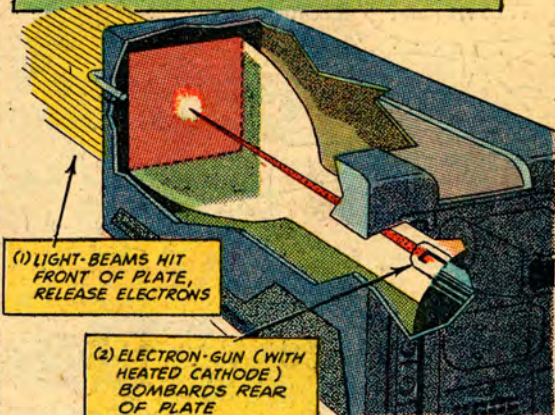
NOW, IN A TELEVISION CAMERA, INSTEAD OF FILM, THERE IS SUCH A LIGHT-SENSITIVE PLATE -- SEALED IN AN ELECTRONIC TUBE...



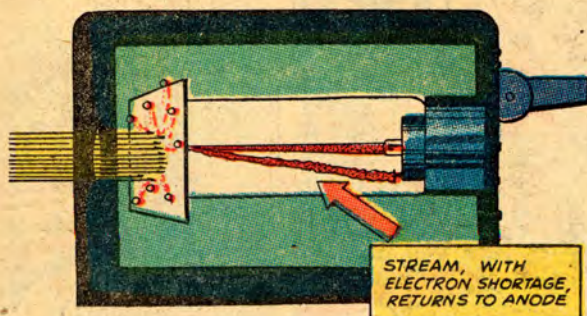
(1) "WHEN LITTLE BEAMS OF LIGHT HIT THE FRONT OF THIS PLATE, ELECTRONS ON THE LIGHTED PARTS OF THE SURFACES ARE RELEASED AND LOST..."



(2) "NOW FROM THE REAR OF THE CAMERA-TUBE, THE HEATED CATHODE OF AN ELECTRON-GUN BOILS OFF A STREAM OF ELECTRONS-- AND SHOOTS THEM OUT IN A CONCENTRATED BEAM TOWARD THE BACK OF THE PLATE..."



"THE PLATE INSTANTLY ABSORBS FROM THE STREAM ITS EXACT NUMBER OF MISSING ELECTRONS... AND--"



THAT MEANS THAT THE AMOUNT OF LIGHT ON THE PLATE AFFECTS THE AMOUNT OF THIS SHORTAGE IN THE ELECTRON STREAM...

THAT'S RIGHT. IN OTHER WORDS, WE'VE MEASURED LIGHT WITH ELECTRIC CURRENT!



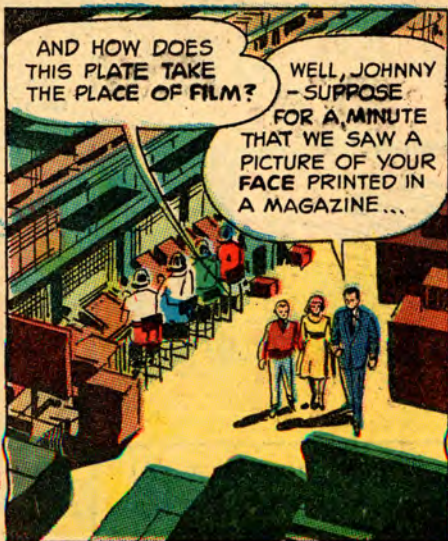
(3) "THE REMAINDER OF THE STREAM, WHICH NOW HAS A SHORTAGE OF ELECTRONS, FLOWS ON TO THE ANODE - TO COMPLETE THE CIRCUIT."

AND, OF COURSE, EACH LITTLE LIGHT CHANGE ON THE PLATE CAUSES AN EQUAL CHANGE IN THE ELECTRIC CURRENT.



AND HOW DOES THIS PLATE TAKE THE PLACE OF FILM?

WELL, JOHNNY - SUPPOSE FOR A MINUTE THAT WE SAW A PICTURE OF YOUR FACE PRINTED IN A MAGAZINE...



"...A CLOSE LOOK AT IT WOULD SHOW IT TO BE MADE UP OF MANY TINY LIGHT AND DARK AREAS..."

NOW, THE PLATE IN THE TELEVISION CAMERA IS ALSO MADE UP OF MANY TINY SECTIONS -- 360,000 OF THEM! NOW LET'S SUPPOSE THE CAMERA-LENS FOCUSES YOUR PICTURE-IMAGE ON THAT LIGHT-SENSITIVE PLATE --

(1) "--IT THROWS DIFFERENT AMOUNTS OF LIGHT ON THESE TINY SECTIONS -- AND EACH SECTION LOSES A DIFFERENT NUMBER OF ELECTRONS."

(2) "NOW, FROM THE REAR OF THE CAMERA-TUBE, THE ELECTRON-GUN THEN DIRECTS AN ELECTRON STREAM BACK AND FORTH ACROSS YOUR IMAGE..."

ELECTRON GUN SCANS IMAGE

"...COVERING ALL OF THOSE 360,000 SECTIONS IN $\frac{1}{30}$ OF A SECOND!"

THIS SPEEDY "SCANNING" RECORDS YOUR WHOLE PICTURE IN A FAST, CHANGING FLOW OF ELECTRONS...

1 ELECTRON BEAM "SCANS" IMAGE...

2 PLATE ABSORBS MISSING ELECTRONS...

3 IMAGE --"RECORDED" IN ELECTRON STREAM -- FLOWS ON TO ANODE...

4 WHICH THEN GOES FROM THE CAMERA, THROUGH A COAXIAL CABLE, TO --

5 CONTROL ROOM...

6 THEN ON TO THE RECEIVING-SET --

7 --WHERE YOUR IMAGE WOULD APPEAR ON THE SCREEN!

WAIT A MINUTE, ED -- IF JOHNNY'S PICTURE IS CHANGED INTO A FLOW OF ELECTRONS... AND SINCE YOU CAN'T SEE ELECTRONS, HOW COULD WE SEE HIM ON THE SCREEN?

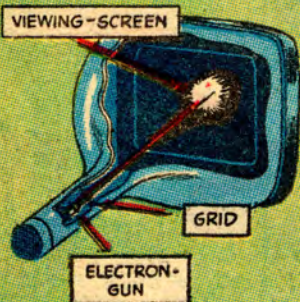
BECAUSE, JANE --

"--JUST AS THE PLATE IN THE CAMERA TUBE LOSES ELECTRONS WHEN HIT BY LIGHT..."

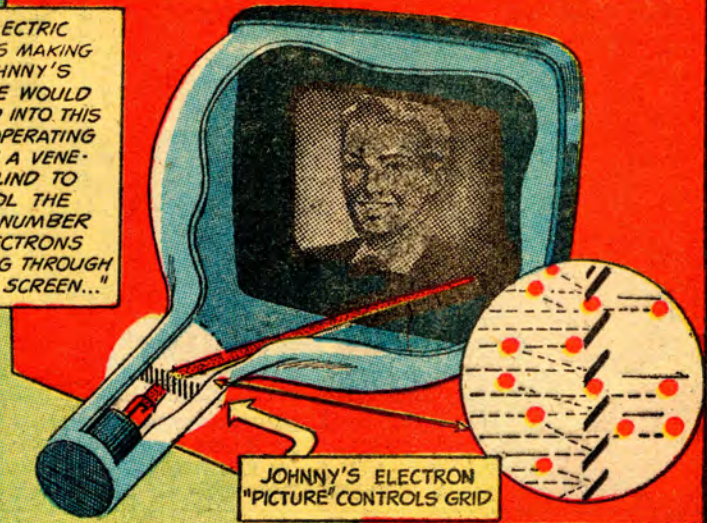
"THE SCREEN IN THE PICTURE TUBE IS CHEMICALLY-COATED TO GLOW WITH LIGHT WHEN HIT BY ELECTRONS!"

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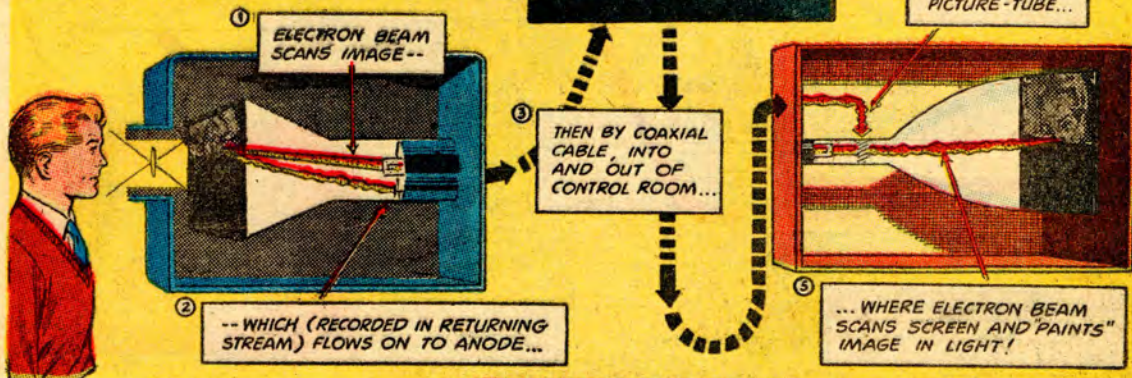
"NOW IN THIS PICTURE-TUBE, AN ELECTRON-GUN SHOOTS A STEADY STREAM OF ELECTRONS--THROUGH A GRID-- TO THE REAR OF THE VIEWING-SCREEN..."



"THE ELECTRIC SIGNALS MAKING UP JOHNNY'S PICTURE WOULD BE FED INTO THIS GRID, OPERATING IT LIKE A VENETIAN BLIND TO CONTROL THE EXACT NUMBER OF ELECTRONS PASSING THROUGH TO THE SCREEN..."



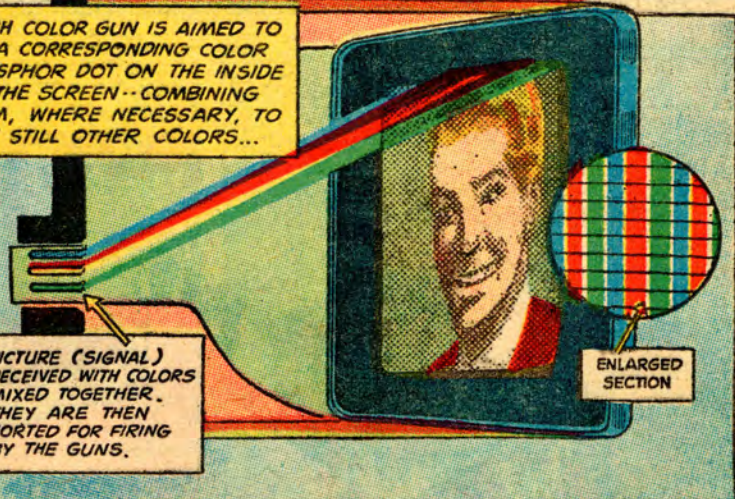
"SO THAT AS THE DIFFERENT AMOUNTS OF ELECTRIC CURRENT HIT THE SCREEN, THEY ARE CHANGED BACK INTO THE EXACT AMOUNTS OF LIGHT WHICH JOHNNY'S IMAGE FIRST THROWS ON THE CAMERA-PLATE."



INCIDENTALLY, COLOR TELEVISION "PAINTS" IMAGES THE SAME WAY, ONLY IT USES 3 GUNS--ONE TO FIRE RED, ONE FOR BLUE AND ONE FOR GREEN...

"EACH COLOR GUN IS AIMED TO HIT A CORRESPONDING COLOR PHOSPHOR DOT ON THE INSIDE OF THE SCREEN--COMBINING THEM, WHERE NECESSARY, TO GET STILL OTHER COLORS..."

PICTURE (SIGNAL) RECEIVED WITH COLORS MIXED TOGETHER. THEY ARE THEN SORTED FOR FIRING BY THE GUNS.

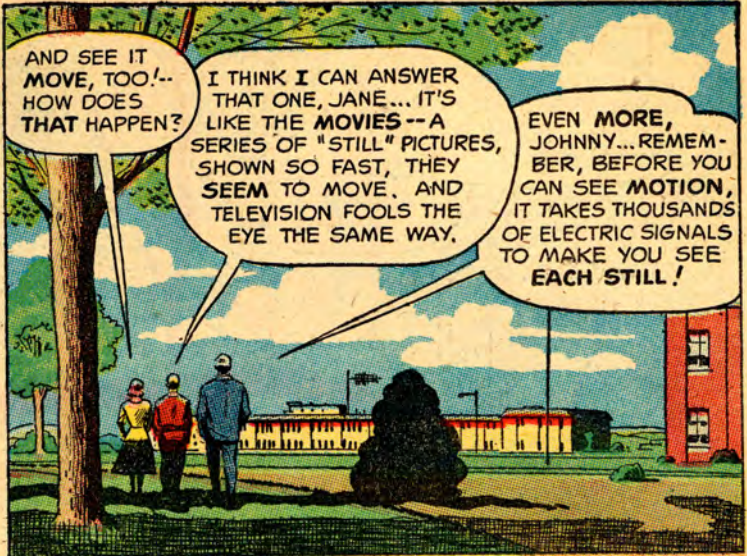


"AND THESE COLORED 'SPOTS' ARE PLACED SO CLOSELY TOGETHER AND HIT SO FAST, THAT YOUR EYE SEES THE PICTURE IN FULL COLOR!"



AND YOU SAY IT TAKES ONLY $\frac{1}{30th}$ OF A SECOND TO RECORD A WHOLE PICTURE ON THE SCREEN?

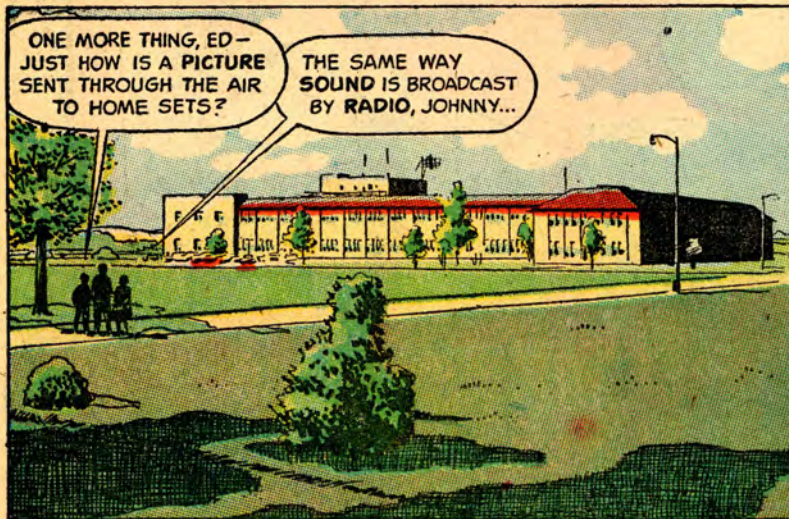
YES, IT'S HARD TO IMAGINE SUCH SPEED, ISN'T IT?--SO FAST THAT WE ACTUALLY SEE A WHOLE PICTURE AT ONCE!



AND SEE IT MOVE, TOO!-- HOW DOES THAT HAPPEN?

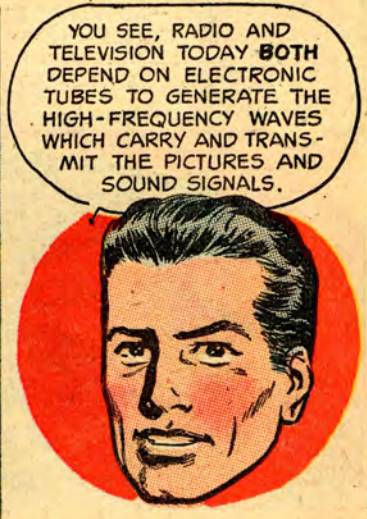
I THINK I CAN ANSWER THAT ONE, JANE... IT'S LIKE THE MOVIES--A SERIES OF "STILL" PICTURES, SHOWN SO FAST, THEY SEEM TO MOVE. AND TELEVISION FOOLS THE EYE THE SAME WAY.

EVEN MORE, JOHNNY... REMEMBER, BEFORE YOU CAN SEE MOTION, IT TAKES THOUSANDS OF ELECTRIC SIGNALS TO MAKE YOU SEE EACH STILL!

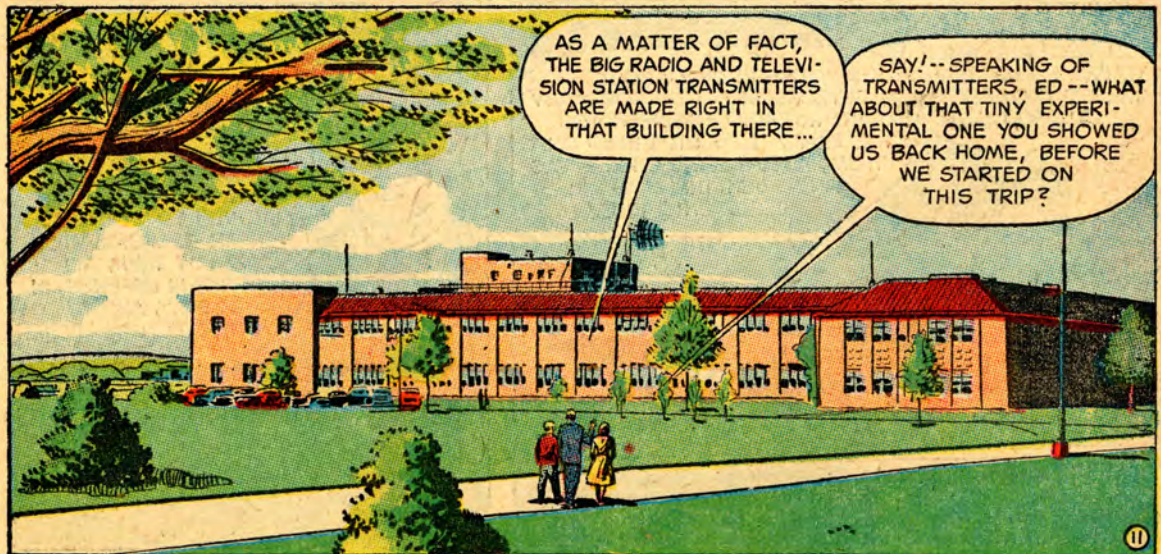


ONE MORE THING, ED-- JUST HOW IS A PICTURE SENT THROUGH THE AIR TO HOME SETS?

THE SAME WAY SOUND IS BROADCAST BY RADIO, JOHNNY...

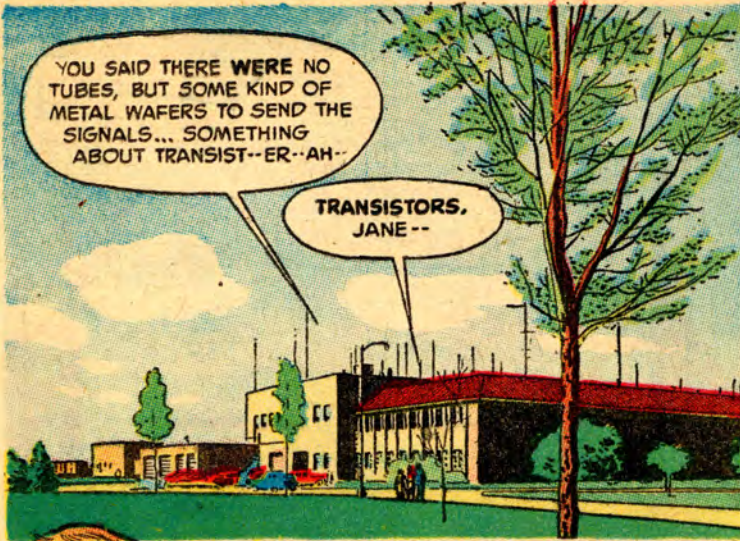


YOU SEE, RADIO AND TELEVISION TODAY BOTH DEPEND ON ELECTRONIC TUBES TO GENERATE THE HIGH-FREQUENCY WAVES WHICH CARRY AND TRANSMIT THE PICTURES AND SOUND SIGNALS.



AS A MATTER OF FACT, THE BIG RADIO AND TELEVISION STATION TRANSMITTERS ARE MADE RIGHT IN THAT BUILDING THERE...

SAY!-- SPEAKING OF TRANSMITTERS, ED --WHAT ABOUT THAT TINY EXPERIMENTAL ONE YOU SHOWED US BACK HOME, BEFORE WE STARTED ON THIS TRIP?



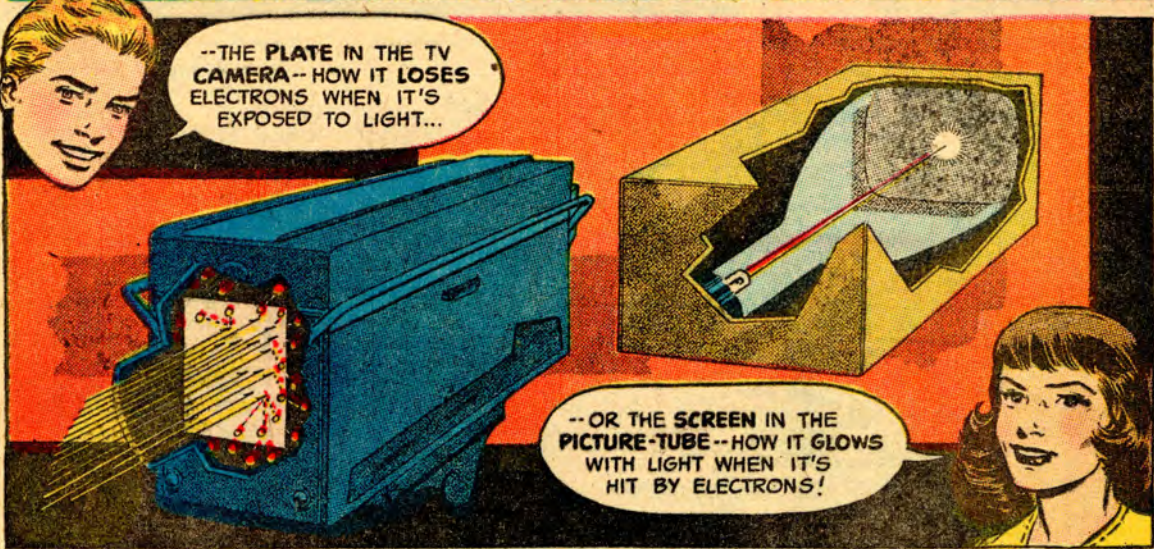
YOU SAID THERE WERE NO TUBES, BUT SOME KIND OF METAL WAFERS TO SEND THE SIGNALS... SOMETHING ABOUT TRANSIST--ER--AH--

TRANSISTORS, JANE--



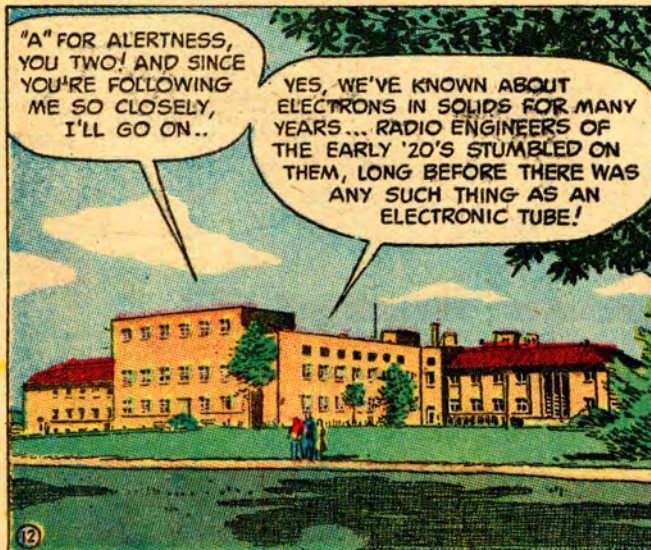
WITH THEM, IT'S POSSIBLE TO CONTROL ELECTRONS PASSING THROUGH SOLIDS. ACTUALLY, YOU LEARNED SOMETHING ABOUT ELECTRONS IN SOLIDS BEFORE, WHEN I WAS TELLING YOU ABOUT--

I KNOW! ABOUT--



--THE PLATE IN THE TV CAMERA-- HOW IT LOSES ELECTRONS WHEN IT'S EXPOSED TO LIGHT...

--OR THE SCREEN IN THE PICTURE-TUBE-- HOW IT GLOWS WITH LIGHT WHEN IT'S HIT BY ELECTRONS!



"A" FOR ALERTNESS, YOU TWO! AND SINCE YOU'RE FOLLOWING ME SO CLOSELY, I'LL GO ON..

YES, WE'VE KNOWN ABOUT ELECTRONS IN SOLIDS FOR MANY YEARS... RADIO ENGINEERS OF THE EARLY '20'S STUMBLED ON THEM, LONG BEFORE THERE WAS ANY SUCH THING AS AN ELECTRONIC TUBE!



BUT WE DIDN'T KNOW HOW TO CONTROL THEIR FLOW... AND SO WE CONCENTRATED ON DEVELOPING THE VACUUM-TUBE, IN WHICH WE COULD FREE AND CAPTURE THEM IN SPACE-- LONG ENOUGH TO CONTROL THEIR PERFORMANCE AND PUT THEM TO WORK-- IN DEFENSE, IN INDUSTRY, AND IN OUR EVERYDAY LIVES...

NOW, ELECTRONS "IN UNIFORM" ARE FORTIFYING OUR DEFENSE SYSTEM WITH "SUPERHUMAN," HIDDEN STRENGTH - IN

"RADAR UNITS - HELPING SHIPS AND PLANES TO 'SEE' THROUGH FOG AND DARKNESS."

"MORTAR LOCATION -- RADAR 'DETECTIVES' SPOTTING AND TRACING ENEMY SHELLS, 'TELLING' OUR GUNS POSITION OF HIDDEN MORTARS ..."

"GUIDED MISSILES -- RELENTLESSLY SEEKING OUT, DESTROYING THEIR TARGETS ..."

"SONAR - TO HELP US 'SEE' THROUGH WATER... REVEALING TO OUR SHIPS AT SEA THE PRESENCE AND POSITION OF THE LURKING ENEMY SUBMARINE!"

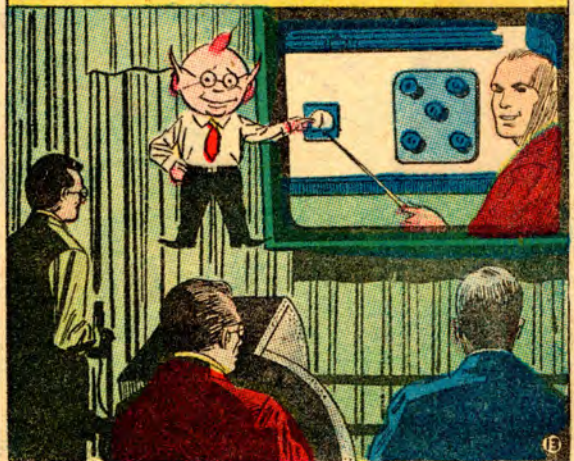
"SONOBUOY 'LISTENING-BOXES' -- TELLING OUR TORPEDO-PLANES WHERE TO DROP THE AMAZING 'HUNTER' TORPEDOES, WHICH UNERRINGLY TRACK DOWN AND DESTROY THE ENEMY SUB!"

AND, IN INDUSTRY - ELECTRONS "IN OVERALLS" ARE SILENTLY AND SWIFTLY AT WORK ...

"ONE OF THEIR BIGGEST JOBS IS CHANGING ALTERNATING CURRENT--"

"THROUGH CLOSED CIRCUIT COLOR TELEVISION, THE BUSY EXECUTIVE IS GIVEN EXTRA 'EYES' AND 'EARS' TO COMMUNICATE WITH HIS COMPANY'S WIDELY-SCATTERED MEN ..."

"-- TO DIRECT CURRENT - ESSENTIAL FOR THE OPERATION OF MACHINE TOOLS, LOCOMOTIVES, ELEVATORS, MINING EQUIPMENT, MAKING ALUMINUM AND STEEL -- AND DOZENS OF OTHER INDUSTRIAL USES!"



AND IN OUR FACTORIES, THE VERSATILE ELECTRON HAS JOINED THE PRODUCTION TEAM...

"-- INSPECTING FOR PINHOLES, OR DEFECTS..."

"-- SORTING FOR COLOR OR SIZE..."

"-- ANALYZING FOR CHEMICAL OR COLOR MAKE-UP..."

"-- ELECTRONIC 'BRAINS' MEMORIZE, COMPUTE IN FANTASTICALLY-SHORT TIME, WITH 'IN-HUMAN' ACCURACY!"

"-- FOLLOWING AND CUTTING COMPLICATED PATTERNS IN METAL."

TWO MILLION COLORS? AND I THOUGHT THERE WERE ONLY TEN THOUSAND?

WELL, YOU'RE ONLY HUMAN...

TIME: 4/1000ths OF A SECOND! CORRECT ANSWER: 74,742,805,859,551,230,625! HOW'D YOU DO?

74,742,805,859,551,230,625

TOOK ME 9 MINUTES -- AND I HAVE 2 ERRORS!

MATCHING CHART FOR 2,000,000 COLORS

BEANS

MEDIUM

WHITE

DARK

LARGE

AND ALWAYS - IN ALL WAYS - THE MIGHTY LITTLE ELECTRON IS QUIETLY, EFFICIENTLY AT WORK AROUND US - PROVIDING A SAFER, HEALTHIER, BETTER WAY OF LIFE...

"RADIO-CONTROLLED TRAFFIC LIGHTS - TO REGULATE THE FLOW IN HEAVY TRAFFIC AREAS..."

"TWO-WAY COMMUNICATION EQUIPMENT FOR AIRCRAFT, MARINE SETS AND AUTOMOBILES..."

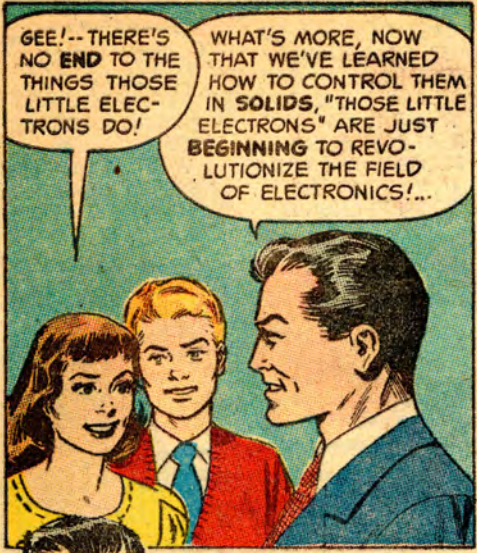
"THE REMARKABLE FACSIMILE EQUIPMENT - THAT BROADCASTS AND PRINTS NEWSPAPER PICTURES AND STORIES BY WIRELESS!"

"EDUCATIONAL TELEVISION - EXTRA TEACHING TOOLS, INTERESTING AND HELPFUL, FOR THE BUSY INSTRUCTOR IN TODAY'S CROWDED CLASS-ROOMS..."

"TELEVISION IN MEDICINE - HELPING TO BRIDGE THE GAP BETWEEN DOCTOR AND DISEASE -- GIVING OUR HEALTH SCIENTISTS A 'CLOSER LOOK' AT THEIR ELUSIVE SUBJECTS..."

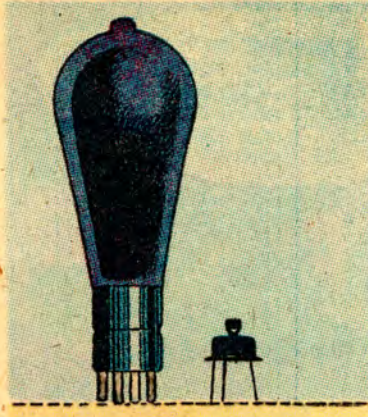
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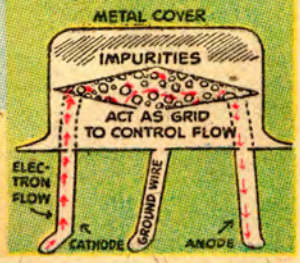
GEE!-- THERE'S NO END TO THE THINGS THOSE LITTLE ELECTRONS DO!

WHAT'S MORE, NOW THAT WE'VE LEARNED HOW TO CONTROL THEM IN SOLIDS, "THOSE LITTLE ELECTRONS" ARE JUST BEGINNING TO REVOLUTIONIZE THE FIELD OF ELECTRONICS!...



"THE NEW TINY SEMI-CONDUCTORS--OR TRANSISTORS--ARE ONLY ABOUT *1/100th* OF THE SIZE OF AN ORDINARY VACUUM-TUBE!..."

"--BUT THEY CONSIST OF THE SAME BASIC PARTS-- EXCEPT THAT TO DO THE WORK OF THE GRID, IMPURITIES ARE INTRODUCED INTO THE SOLID METAL TO CHECK THE FREE FLOW OF ELECTRONS."



YES, THESE TINY SOLIDS ARE MAKING THE ELECTRONIC DREAM-HOUSE A REALITY.

HOME MOVIES --OR YOUR FAVORITE TV SHOW-- WILL BE TAPED, PLAYED BACK ON YOUR REGULAR TV SCREEN -- IN FULL COLOR AND WITH SOUND-- THE SAME PICTURES YOU "SHOT" A FEW MINUTES BEFORE!

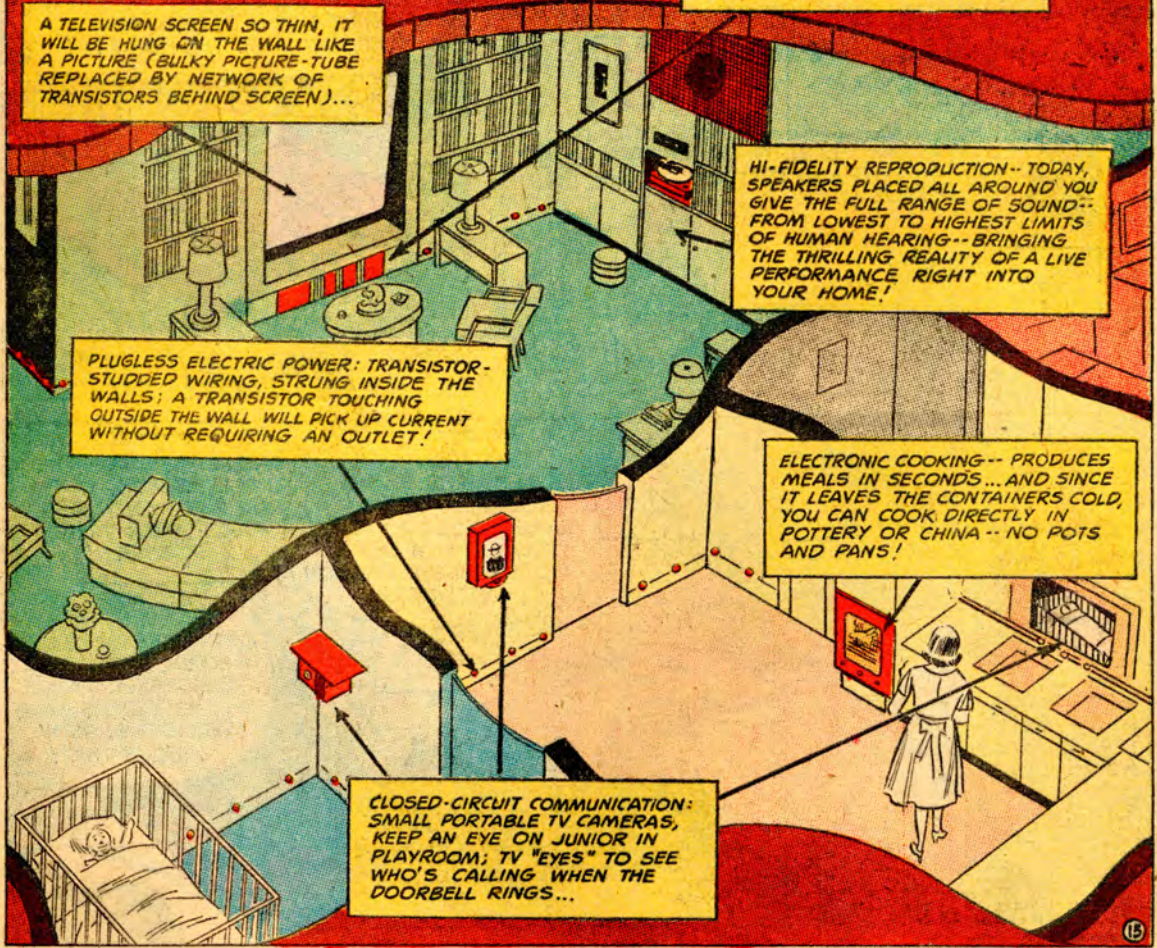
A TELEVISION SCREEN SO THIN, IT WILL BE HUNG ON THE WALL LIKE A PICTURE (BULKY PICTURE-TUBE REPLACED BY NETWORK OF TRANSISTORS BEHIND SCREEN)...

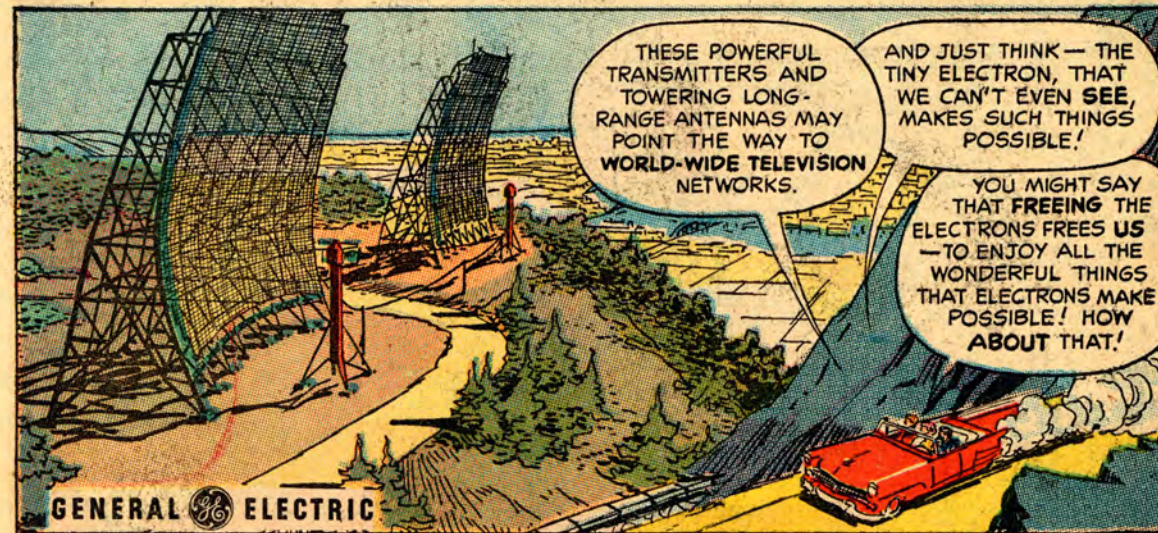
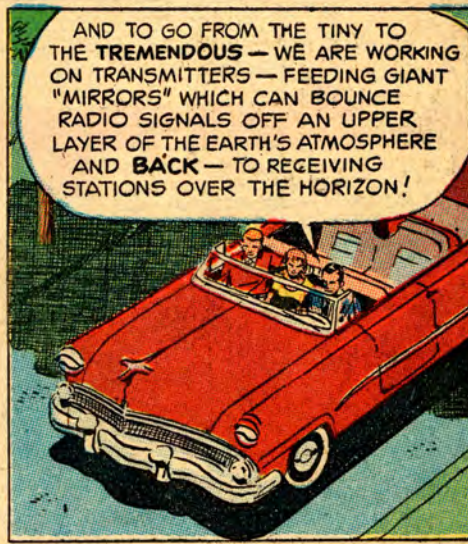
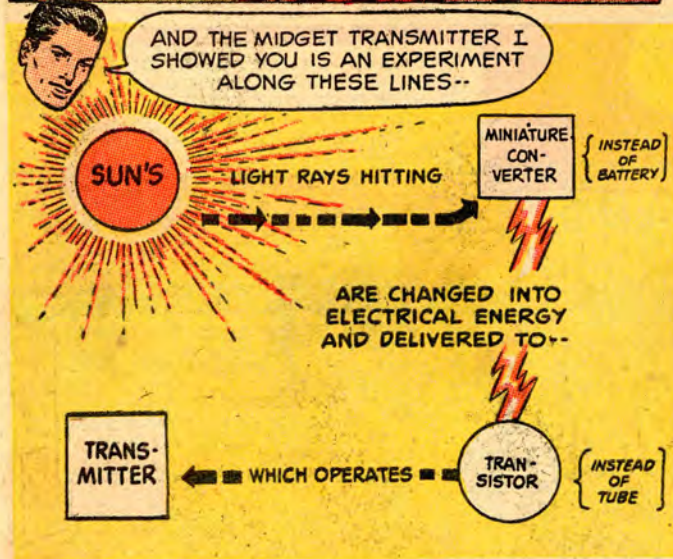
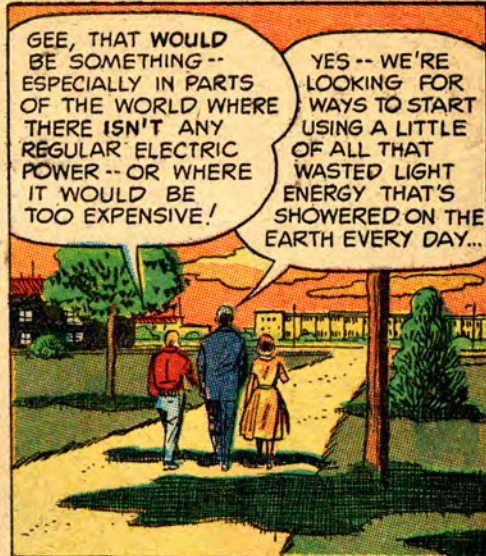
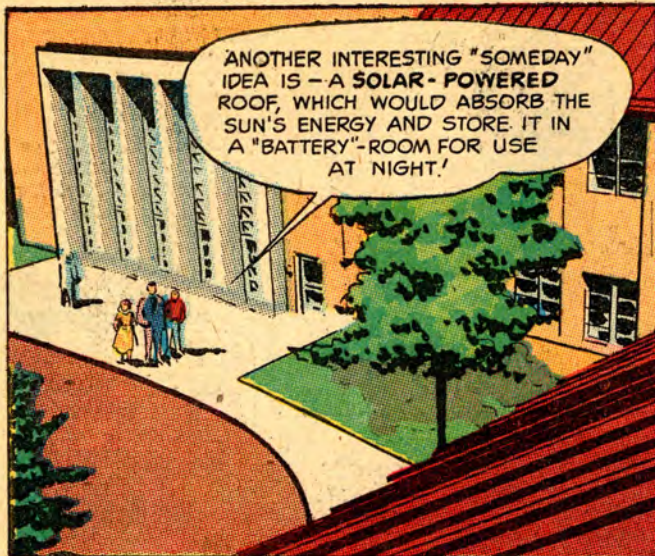
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CLOSED-CIRCUIT COMMUNICATION: SMALL PORTABLE TV CAMERAS, KEEP AN EYE ON JUNIOR IN PLAYROOM; TV "EYES" TO SEE WHO'S CALLING WHEN THE DOORBELL RINGS...





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