Proceedings of
The Radio Club of America

Volume 38 No.1 June, 1962

Founded 1909

THE DYNAQUAD

A SOLID STATE ELECTRONIC SWITCH

by

C. E. ATKINS

SEMICONDUCTOR DIVISION of TUNG-SOL ELECTRIC INC.

EAST ORANGE, NEW JERSEY

THE RADIO CLUB OF AMERICA, INC.

11 West 42nd Street ★ ★ ★ New York City

FOUNDED 1909 NEW YORK, U.S.A.

The Radio Club of America

ORGANIZED FOR INTERCHANGE OF KNOWLEDGE OF THE RADIO ART, THE PROMOTION OF GOOD FELLOWSHIP AMONG THE MEMBERS THEREOF, AND THE ADVANCEMENT OF PUBLIC INTEREST IN RADIO.

RCA

11 West 42nd Street, New York City **Telephone — LOngacre 5-6622**

Officers for 1962

President
R. H. McMann, Jr.

Vice President
Ralph R. Batcher

Treasurer
Joseph J. Stantley

Corresponding Secretary
James Morelock

Recording Secretary
Albert F. Toth

Directors

Robert M. Akin, Jr.
Ernest V. Amy
Horace Atwood, Jr.
Ralph R. Batcher
John H. Bose
George E. Burghard
Frank H. Shepard, Jr.
Frank A. Gunther
Samuel N. Harmatuk
Harry W. Houck
Walter A. Knoop
Raymond E. Lafferty
Jerry B. Minter

Committee Chairmen - 1962

Affiliations
Walter Knoop

Armstrong Memorial
George E. Burghard

Budget
Joseph J. Stantley

Banquet & Entertainment
Albert F. Toth

Legal Counsellor
George E. Burghard

Manuscript
George Washington, Jr.

Medals
Harry W. Houck

Membership
Robert Finlay

Papers & Meetings
Alexander Proudfit

Publications
Ralph R. Batcher

Publicity
Lloyd Jacquet

PROCEEDINGS OF THE RADIO CLUB OF AMERICA
PUBLICATION BOARD

Editorial Director	Ralph R. Batcher
Production Manager	James Morelock
Advertising Manager	George Washington, Jr.
Papers Procurement	George Washington, Jr.

PROCEEDINGS OF THE RADIO CLUB OF AMERICA

Volume 38 June, 1962 No. 1

THE DYNAQUAD*

A SOLID STATE ELECTRONIC SWITCH

by

C. E. ATKINS

SEMICONDUCTOR DIVISION of TUNG-SOL ELECTRIC INC.

EAST ORANGE, NEW JERSEY

A novel four-layer PNPN semiconductor switch made by a simple alloying process, the Dynaquad is capable of many interesting applications. This paper describes in very general terms the manufacturing process, theory of operation and some of the circuit arrangements utilizing the device.

The Dynaquad is a four-layer PNPN semiconductor device made by a simple alloying process. It was invented at Tung-Sol by Benedict Carlat and Robert H. Fidler, Jr. Like the thyratron, a well known electronic tool, the Dynaquad is essentially a switch of the S.P.S.T. variety. It has two useful positions - "off" or "on".

In a thyratron, if you are very careful to restrict the space current to a minute value, you can develop a family of curves which are just like those of a hard vacuum tube. At larger current levels, however, the device "fires" and the current is then limited by the load resistance and source e.m.f. or, in a ruinous extremity, by the emission capability of the cathode.

In like manner, the Dynaquad is a poor transistor at very low current levels, above which, however, it too will "fire" whereupon the current passed is largely determined by the external circuit.

Figure 1 shows the device as a sandwich of four layers (1A) and in approximate physical likeness (1B). The Dynaquad is made by the alloying process. Its base is a dice of N type germanium approximately .070" square by .004" thick. The emitter is a pellet approximately .012" in diameter of indium with some gallium in it, alloyed to one side of the base in the conventional manner. This consists in placing the parts in proximity with suitable jigging in an alloying oven at a temperature of several hundreds °C. The indium melts and dissolves some of the germanium. Later, cooling takes place, and as the molten germanium recrystallizes it will contain some of the indium as a doping agent. Because indium is an "acceptor" type of impurity, the recrystallized germanium containing it is of the P type.

A somewhat similar procedure is used on the collector side except that the sphere is larger (.016") and it contains a trace (about .5%) of antimony dissolved in the indium. The alloying proceeds as with the emitter except that when the germanium recrystallizes there is a differential segregation between the indium and antimony, thus forming two junctions instead of one. Figure 1B shows, in a general sort of way, what the finished junction assembly looks like. The junction is then mounted on the usual TO-5 or TO-18 stem and in appearance is no different than the regular low power transistor.

To assist in imparting an elementary understanding of the Dynaquad action it is helpful to review the behavior of PN junctions generally. In a semiconductor crystal, such as germanium, it is possible to imbed certain kinds of foreign atoms by substituting the stranger for one of the host atoms. This process is called doping and if there is one foreign atom for every thousand host atoms one calls it "heavy" doping, whereas if there is one foreigner per million host atoms the doping may be referred to as "light." To be technically useful, doping atoms are those with <u>three</u> or <u>five</u> valence electrons as compared to the <u>four</u> valence electrons possessed by the main crystal of germanium. It is useful to picture the geometry of a crystal as the result of an interplay of forces; those which are electrical in nature and those which are quantum-mechanical. The binding facility which gives the crystal germanium its special structure is a talent the valence electrons have, which permits them to be shared by neighboring atoms so that each atom appears to have eight valence electrons instead of the normal four.

The writer does not know how well this phenomenon is "understood" by modern physics. In any event it is not necessary for the present purposes to know more than the very general fact that an "arrangement" of 8 electrons - the so-called "octette" - is remarkably stable. It is this feature to which we attribute the "nobility" of the rare gases, neon, argon, krypton, etc. To achieve this octette in a crystal where the assembled atoms

*Presented at the Radio Club of America January 16, 1962

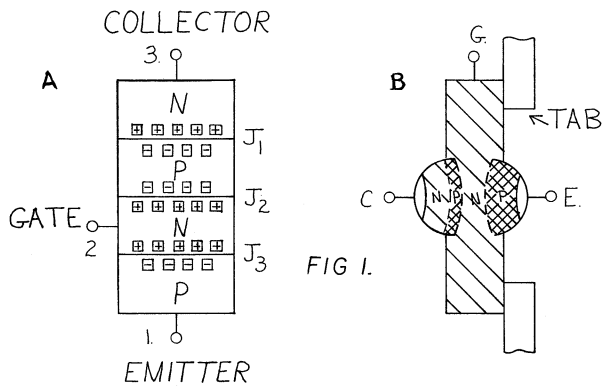


FIG 1.

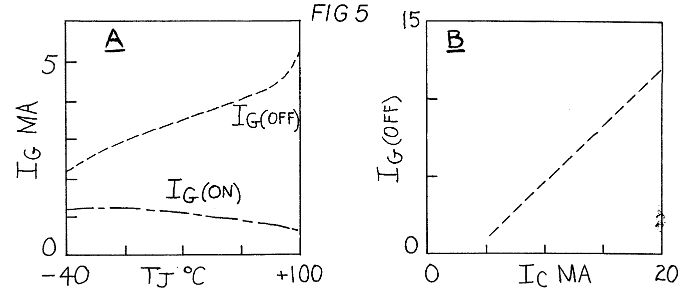


FIG 5

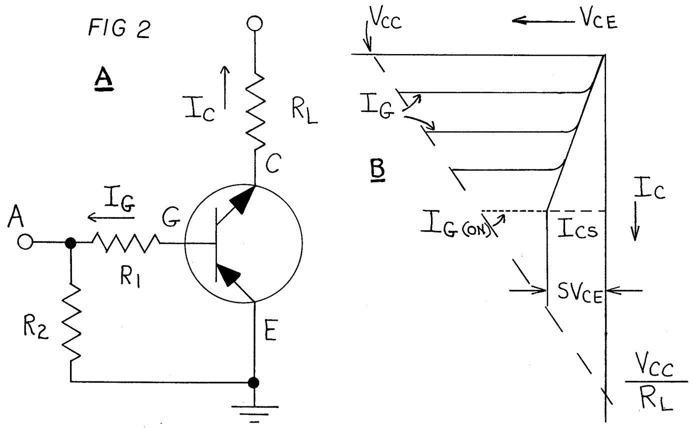


FIG 2

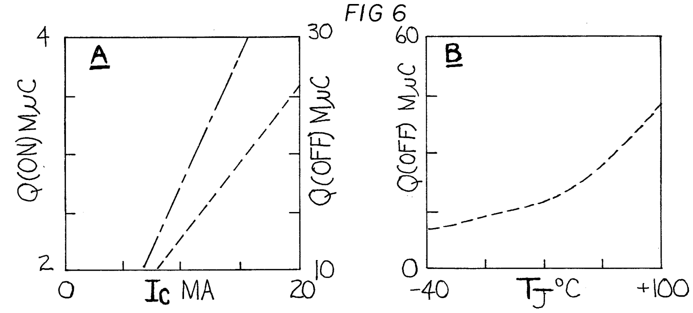


FIG 6

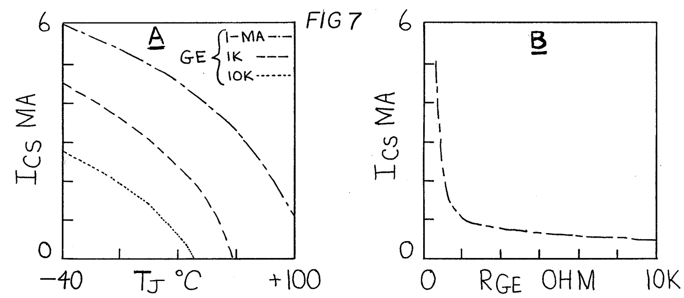


FIG 7

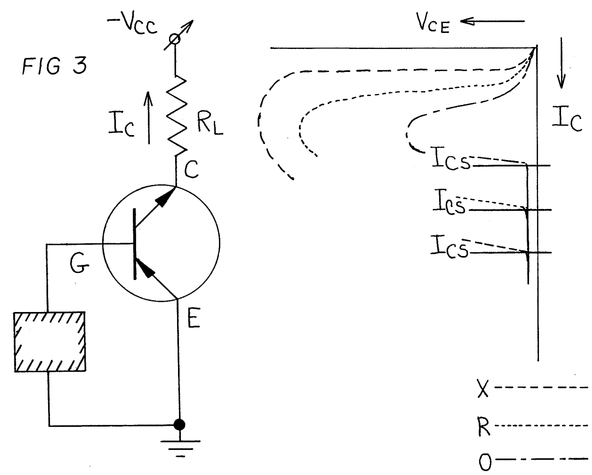


FIG 3

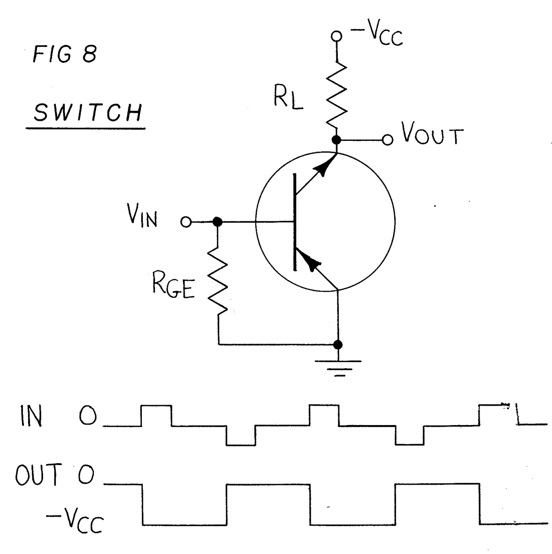


FIG 8

SWITCH

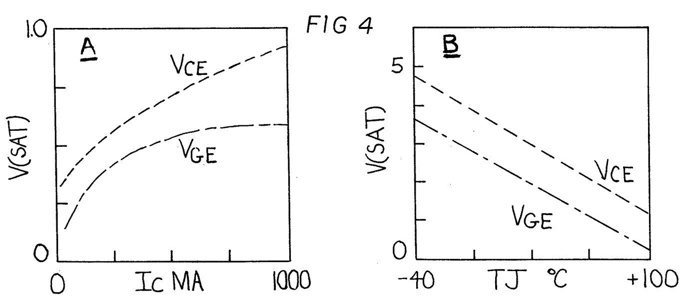


FIG 4

have only four valence electrons requires a special positioning of the atoms with respect to one another so that the right sort of sharing process is fulfilled. One should always keep in mind that this is a mechanical phenomenon which can take place with or without space-charge neutrality. In doping, the foreign atom can be fitted into the crystalline array only by distributing the electrical balances to achieve the mechanical lock-in. Thus, if the dopent has five valence electrons where only four are required for binding, one electron will be surplus in the mechanical sense.

Although its charge is, of course, required to neutralize the extra positive charge contributed by the nucleus of the foreign atom. It can be pictured as hovering somewhere in the region of this atom so that, viewed from a distance, there is space-charge neutrality. However, this electron can momentarily wander away from this precise location without anything catastrophic happening, and it can, of course, be replaced by another electron. Such electrons are called "donors" because they have been donated by the impurity atom and because they are not part of the binding arrangement between the atoms. They are free to move about the crystal in response to an electric field and of course they are whimsically cavorting with the temperature-induced motions exhibited by free particles everywhere. (There are, of course, thermal oscillations of the crystal lattices but these are not chaotic or else the crystal would be ruptured).

It is even possible to remove these electrons from the crystal without breaking up the orderly array of atoms if one has a sufficient electric field, because while the electrons individually give us space-charge neutrality by compensating for the positive charge due to the doping atoms an applied field may supply external compensation.

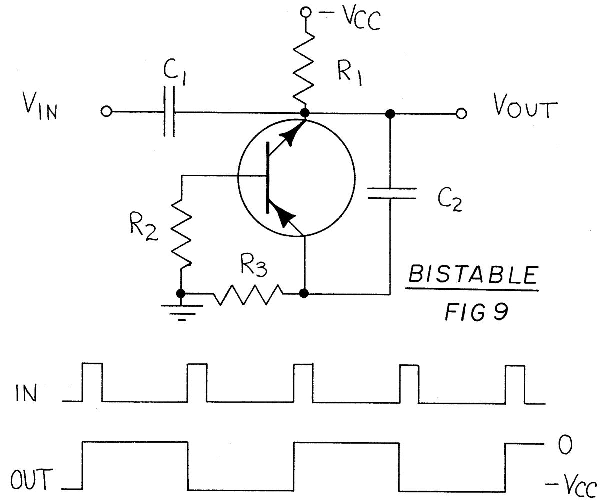
If the foreign atom has a valence of only three, the quantum-mechanical binding arrangements are achieved by robbing an electron from an adjacent atom. This locks-in the foreign atom, although somewhere nearby an electron is missing from the valence octette of the crystal. This state of affairs is not permanently stable. The cohesiveness in this minute region of the crystal is not altogether complete and it is likely that an electron from a second neighbor might be enticed into the octette of the first neighbor. The rate at which this happens is, of course, a function of temperature and under normal conditions this atom hopping process is going on all the time. Such vacancies are called "holes." The electrons involved in this complex process cannot respond directly to an electric field in such a way as to constitute an electric current. However, their orbital motions can be warped by an electric field, resulting in the apparent motion of positive charges with respect to the field.

The foreign atom responsible for this situation is called an acceptor and the resulting crystal is called P type. When P type and N type germanium forms a junction, the charge carriers will migrate as the result of a density gradient from a region of high density to one of low density. As electrons leave the N region they leave behind a section of positively-ionized atoms. Accordingly an electric field is built up, tending to limit or arrest the diffusion process. A corresponding situation obtains on the P side of the junction where a diffusion of holes results in an excess of negative charge.

An external electric field can either assist or counteract this process depending on its polarity. If a negative potential (via an ohmic contact) is applied to the N region and a corresponding positive potential is applied to the P region, the diffusion process will be assisted since these external potentials tend to overcome the electric field caused by the locked-in ions. Conversely, if the N region receives a positive potential more electrons will be swept away from the depletion region near the junction leaving an even greater number of positive ions behind and thus enhancing the barrier due to the electric field. This is the manner in which the typical PN junction performs as a rectifier.

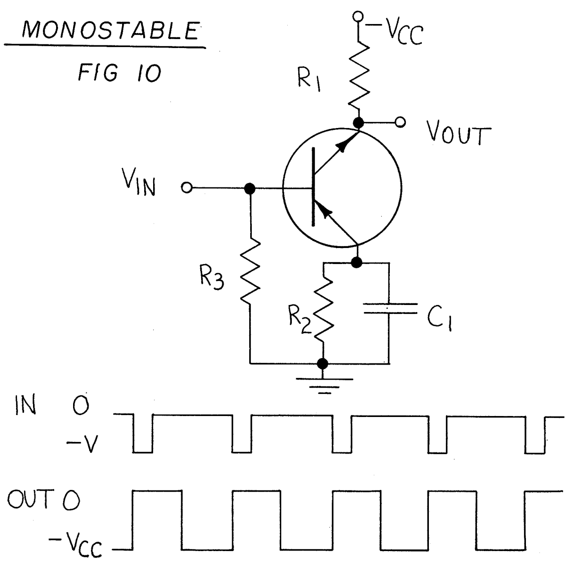
In the Dynaquad there is a floating junction between the collector and base. This is a key to the operation of the device. The junction nearest the collector contact appears forward-biased and this would be true if the next junction alone terminated in an ohmic contact. However, such is not the case as this P zone terminates in an N zone (rather than an ohmic contact) which is, in turn, part of a PNP transistor. Let us label these junctions J 1, 2, 3, going from the collector toward the emitter in Figure 1A.

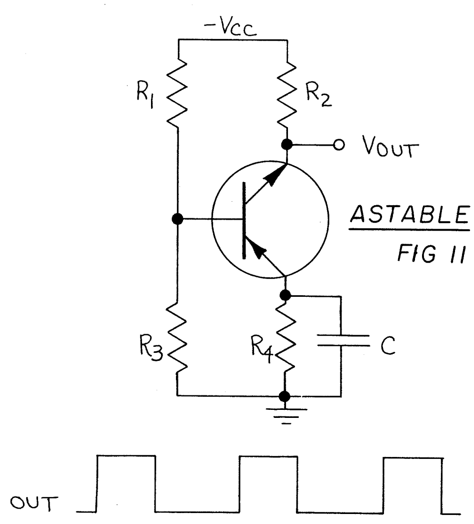
Imagine the gate is grounded, or better still is maintained at a slight positive potential with respect to the emitter which is grounded. Under these circumstances junction J_3 is back-biased and only a tiny residual current will flow across it. If the collector has a potential of 10 or 20 volts (negative with respect to ground) applied to it, one can understand how junction J_2 will also be back-biased just as it would in the case of an ordinary PNP transistor. This state of affairs is illustrated by the locked-in impurity ions shown as little polarized squares in the vicinity of the junctions in Figure 1A. If now the gate potential is shifted from slightly positive to slightly negative (with respect to ground), junction J_3 will now have a forward bias and electrons can flow from N to the P region. Conversely holes can flow from the P to N regions across J_3. Since the P region is more heavily doped than the N region by a ratio of approximately 100 to 1, many more holes will enter the N region than electrons



BISTABLE
FIG 9

MONOSTABLE
FIG 10





ASTABLE
FIG 11

COUNTER

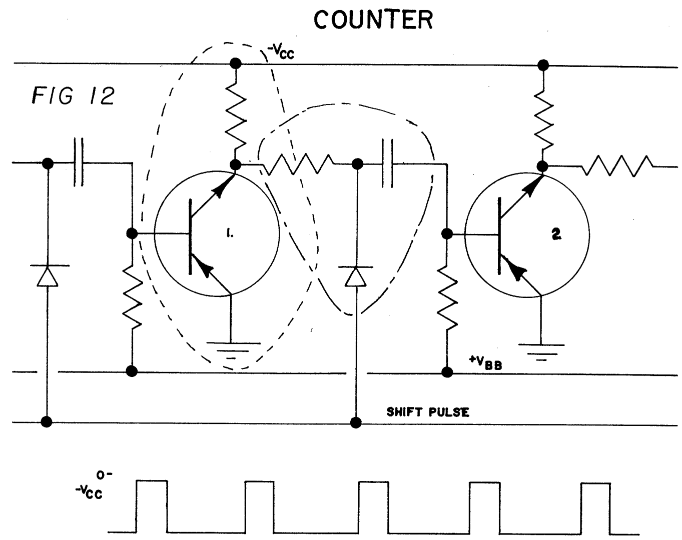


FIG 12

SHIFT REGISTER

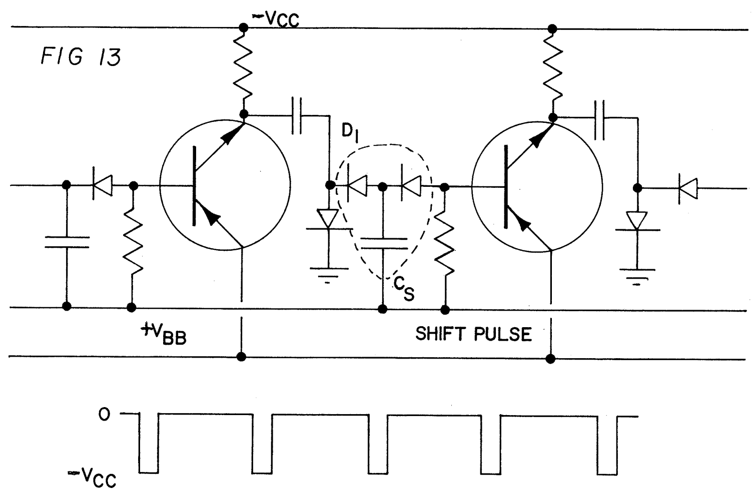


FIG 13

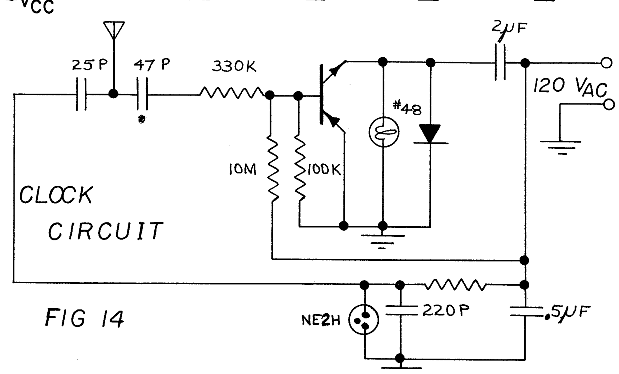
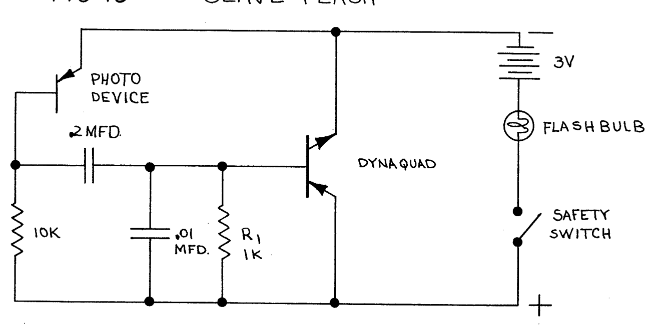


FIG 14

FIG 15 SLAVE FLASH



entering the P region. These holes will diffuse across the N region to junction J_2 and a high percentage of them will diffuse across this junction into the second P region. If junction J_1 were an ohmic contact we would have a conventional PNP transistor and this diffusion of holes would then constitute the collector current.

However, because J_1 is a junction and not an ohmic contact, a percentage of these holes are trapped in the upper P region and serve to greatly alter the space-charge here. Because of this altered space-charge, electrons can flow in greater numbers from the collector N region into the P region beneath it. Here, large numbers of them diffuse into the gate region and are collected by the gate's ohmic contact. These processes are cumulative and once a certain current level is reached the protective e. m. f. 's at the junctions are completely swamped out and neutralized by the flow of charge carriers. All junctions then become forward biased and very large values of current can flow.

If the emitter or collector circuit is opened the excess charge carriers will rapidly disappear and the non-conducting state is soon restored. Also, it is possible, by pumping enough electrons out of the gate with a positive source, to bring the current level below the sustaining value, thus turning the device off.

Figure 2 illustrates the use of the Dynaquad and the symbol representing it. R_1 is a limiting resistor, R_2 the load resistor of a driving stage and R_L the load resistor for the Dynaquad. With such a circuit the family of curves shown in Figure 5 is obtained. These curves are not to scale inasmuch as the collector current prior to firing is of the order of a few microamperes whereas after firing the collector current is likely to be 10's or 100's of milliamperes.

Figure 3 illustrates how collector current varies with collector voltage with different gate circuit terminations, back bias giving the highest sustaining current and a floating base giving the lowest with various resistance values giving an Ics in between.

In Figure 4 the variation of saturation voltage with collector current (4A) and with junction temperature (4B) is shown.

Figure 5 shows the relationship between gate current and junction temperature and collector current respectively.

Figure 6A illustrates the relationship between collector current and the energy required for turning the device on or off while Figure 6B shows the energy requirement varying with temperature.

Figure 7A relates junction temperature to sustaining current for various gate to emitter resistances. In 7B the resistance relation is exemplified at 25°C.

The Dynaquad may be used as a latching relay and in a variety of switching applications. It is possible to employ it as a multivibrator of the bistable, monostable, or astable variety with a substantial saving in parts with respect to the more conventional circuitry using a pair of transistors and the associated coupling components.

Figure 8 indicates the use of a Dynaquad as a switch. The device may be switched on with a signal supplying only a few microwatts of power and may be turned off with a few milliwatts. The energy required to switch off will of course depend on the collector current. The turn-off gain is approximately 2 so one half the collector current must be supplied as positive bias current to turn the Dynaquad off.

Figure 9 is a Dynaquad bistable. Let us assume the Dynaquad is initially in the off condition and we wish to turn it on. This will require a positive pulse at the input. This pulse is transmitted through C_1 and C_2 to R_3 and the emitter of the Dynaquad. There must be enough energy in the positive pulse to sustain the load imposed by R_1 and R_3. Fortunately the energy needed to turn on by the emitter is very small. After the Dynaquad is switched on it will draw current from the power supply $-V_{cc}$ which is largely limited by the resistor R_1 in series with the Dynaquad and the approximate parallel of R_2, R_3. Since most of the drop appears across R_1 the collector of the Dynaquad will be close to ground potential.

All that is required to turn the device off is a second positive pulse which serves to lower the potential of the collector below that necessary to maintain essential current. This makes the Dynaquad turn off. The energy of the positive pulse must be limited to that sufficient to do the job. If this pulse is too big the collector can be positive during a turn-on pulse in which case the device will not switch on or if there is a tail on the pulse during the switch-off phase it is possible to have the device immediately turn back on.

Figure 10 shows the Dynaquad as monostable multivibrator. Circuits of this kind are employed where a uniform pulse is needed for control purposes or where there are impedance matching problems. In Figure 10, initially C_1 is devoid of charge and remains this way until such time as a negative going input signal fires the Dynaquad, whereupon C_1 will charge through R_1.

A potential will be reached such that the voltage across the Dynaquad will no longer provide the sustaining current and it will switch off at this time. The output potential will again assume the value $-V_{cc}$. The slight modification in Fig. 10 shown in Fig. 11 provides us with a free running or so called astable multivibrator. Here the condenser and the emitter leg behave as in Fig. 10 with the additional feature, however, that when this condenser is discharged through R_4 a point is reached where the Dynaquad fires again because of the forward bias provided through R_1.

The foregoing circuits are basic building blocks from which all sorts of more elaborate circuitry can be fabricated. Fig. 12 shows one way in which the Dynaquad can serve in a counter. This circuit functions as follows: Assume Unit 1 is in the off condition while Unit 2 is on, that is to say drawing current. Not shown is Unit 3 which is a repetition of Unit 1 in all respects except for its position on the chain. A positive going pulse appearing on the control buss will then turn Unit 2 off, since Unit 1 is off nothing can happen to it. As Unit 2 turns off its collector potential will rise to $-V_{cc}$ and this in turn will provide a negative pulse which will pass through the coupling condenser and turn Unit 3 on. This procedure may be repeated thus shifting the "on" Dynaquad from position to position in a manner useful for counting.

The counter can be fabricated with plug-in circuit boards. The evolution of these boards is illustrated in the photograph P-1 where the large board is a counter circuit using conventional transistor flip-flop circuitry the smaller board in the same picture shows the simplifications possible when the Dynaquad is used instead. The smallest board is a later embodiment of the same circuitry where a Dynaquad and associated components for each stage have been potted in epoxy resin and plugged into a much smaller baseboard. Some of the uses of this device will be mentioned briefly later in the paper.

A variation of this circuitry shown in Fig. 13 provides us with a shift register. A facility of this kind is useful to store intelligence or to provide an index. In Fig. 13 negative pulses activate this system. Let us assume Unit 1 is in the "on" condition in which case the negative pulse applied to the emitter will turn Unit 1 off. In like manner all other units in the system will be turned off. Of course if a respective unit is already in the off state the turn-off signal does not alter its condition. Since we assumed Unit 1 to be in the "on" condition the act of turning it off with the shift pulse will cause the collector potential of this Dynaquad to assume the value of the source $-V_{cc}$. As this happens a negative going pulse will be passed through the coupling capacitor and diode D_1 into storage capacitor C_s. All this takes place during the rise time of the shifting pulse and perhaps during some of the interval that the shift pulse is at a maximum. When the shift pulse flows back to the base line the negative charge in C_s is passed on to Dynaquad #2 thus turning it on. Storage capacitor C_s is needed because Dynaquad #2 cannot be turned on until after the shift pulse has returned to zero.

The Dynaquad lends itself readily to a variety of control functions. Two that are interesting are a table lamp that is turned off or on merely by touching it and an electric clock the face of which can be illuminated for viewing in the dark merely by reaching over and touching the case of the clock.

Fig. 14 is a schematic of the clock circuit. The antenna symbol is used to indicate the clock case or a substantial portion of it which one touches to activate the system. A small #48 panel lamp is connected to the power line through a 2 microfarad paper condensor. This lamp is normally not energized because during the positive half cycle it is shorted by diode D_1 while during the negative half cycle it is shorted by the Dynaquad TS1595. This Dynaquad is maintained in the "on" state because pulses generated by a neon lamp relaxation oscillator are fed to its base through 2 small capacitors and a series resistor. Turn-off bias for the Dynaquad is supplied from the B+ through a 10 megohm resistor but the pulses normally reaching the base are large enough to override this bias. However, when one touches the clock case, body capacity which is approximately 100 micromicrofarads reduces the magnitude of the pulses so that turn-off bias is effective and the Dynaquad no longer draws current during the negative half cycle. This means that the current can now flow through the panel lamp and it will accordingly be lighted during the interval ones hand is in contact with the case.

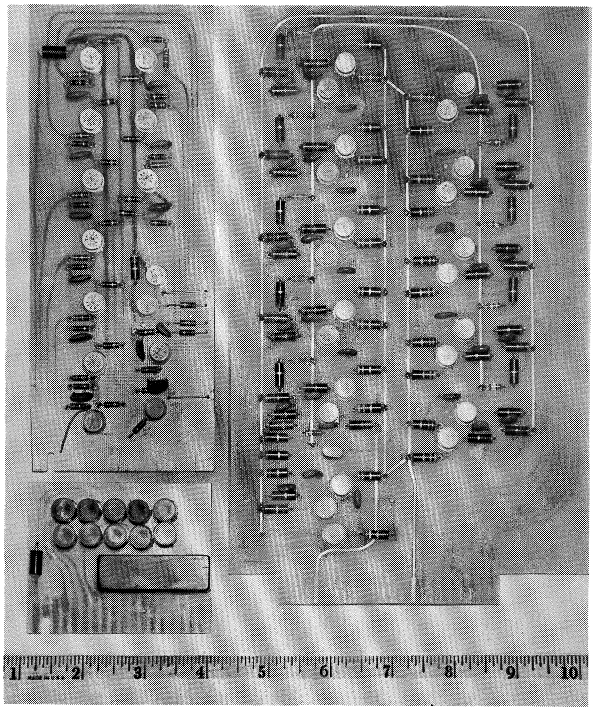
By substituting a relay for the lamp in this circuit it is possible to control higher voltage and more power, and if this relay is of the stepping variety then it is possible to alternately turn off and turn on a table lamp or other appliance with successive touching of a control plate.

One of the most dramatic applications of the Dynaquad is its utilization in a wireless slave-flash unit for photographic purposes. When the Dynaquad fires a peak current of one or more amperes flows for about a millisecond and this ignites the flash bulb, after which the Dynaquad is restored to its previous condition because a spent flash bulb is a pretty good open circuit. In the schematic of Fig. 15 a solid state photo-sensor translates the light energy of a master flash into a pulse which passes through the coupling condensor to the gate of the Dynaquad. A vacuum photodiode may be used instead of the semiconductor photo-sensor with the aid of an emitter follower between it and the Dynaquad.

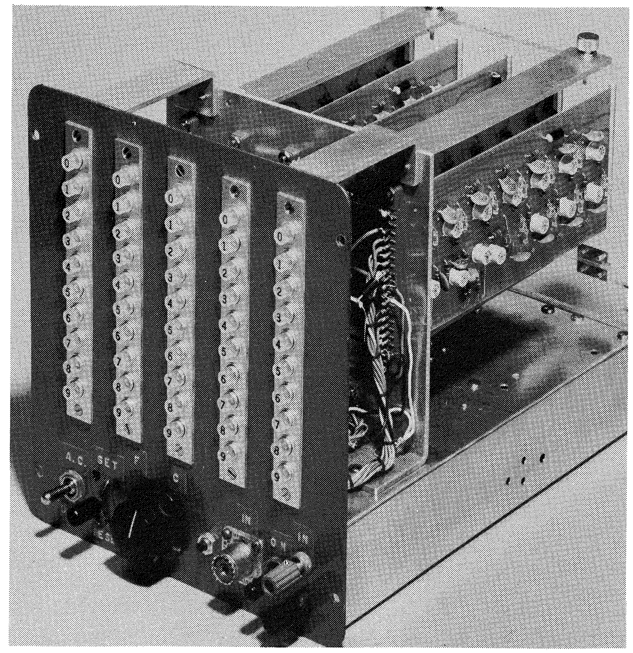
The foregoing are some of the interesting applications of this device. Many more are being evolved and will be disclosed in the near future.

We are indebted to Arthur F. Cake for many of the circuits employing this PNPN switch and to Donald Richardson and Robert Zilkowski, all of Tung-Sol's Semiconductor Division for valuable technical assistance on this project.

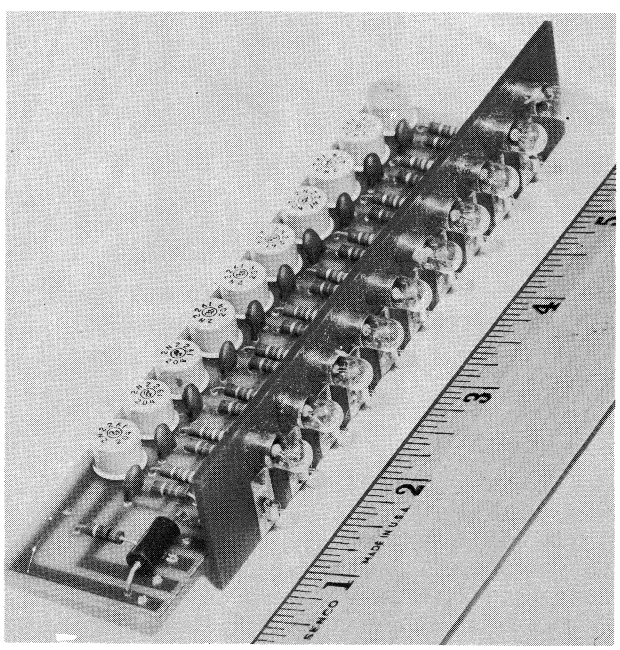
* * * * * * * * * * *



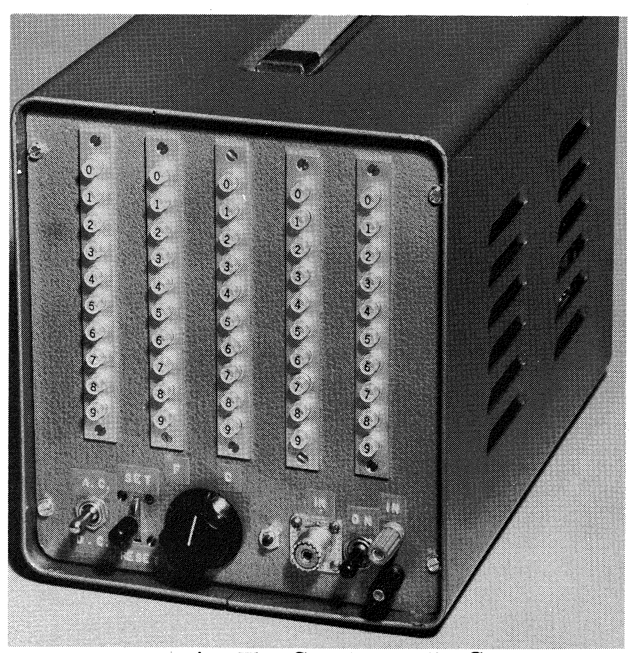
Photograph 1 - Counter circuitry employing the Dynaquad, upper right, is contrasted to standa. transistor practice at the left. The board at the lower left is a further step in the miniaturization process using the Dynaquad.



Photograph 3 - A 100 KC Counter using Dynaquads.

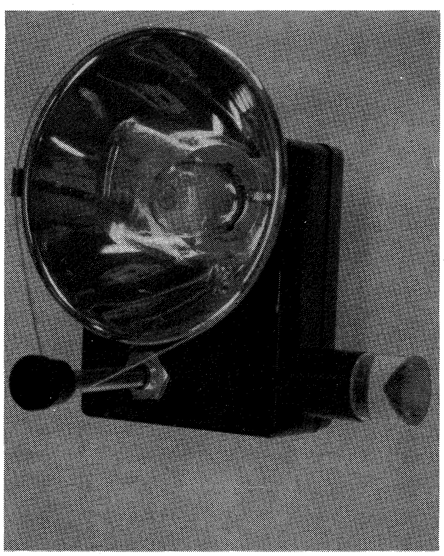


Photograph 2 - A compact assembly with read-out lamps.

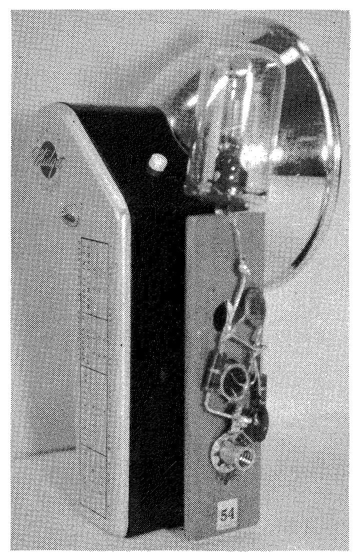


Photograph 4 - The Counter in its Case.

Photograph 5 - A Touch Control Lamp. Merely by means of manual contact with the base, a lamp may be alternately switched on and off.



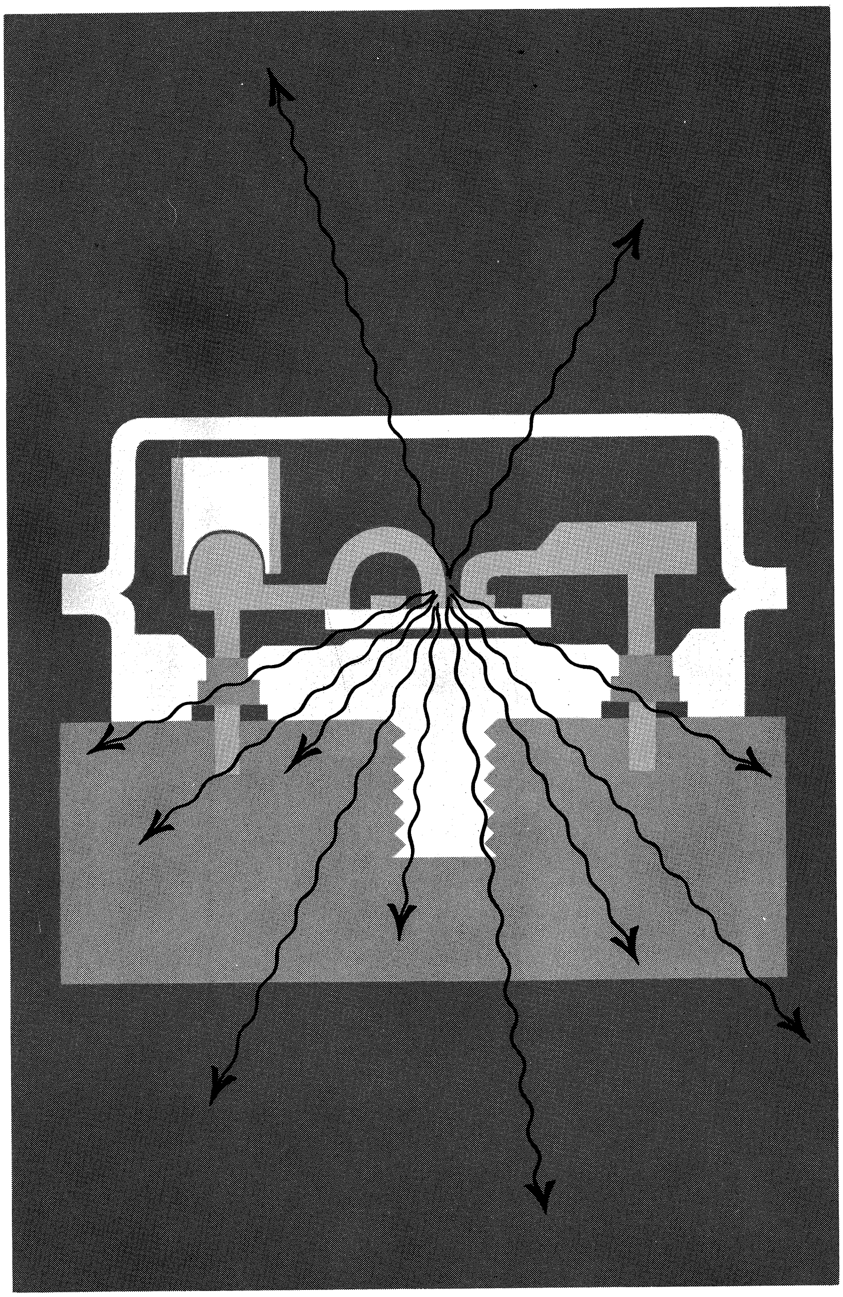
Photograph 6 - A photoflash slave unit in which light picked up by a photo sensor actuates a Dynaquad to energize a flash bulb.



Photograph 7 - A slave photoflash with cover removed revealing the simple circuitry.

EDITORIAL

The Club stock room has extra copies of some of the Proceedings that have been published during the past, including a quantity of some of the most important articles, such as the several papers delivered by Howard Armstrong, the 1-BCG issue and others. It also seems that many of our members have stocks of past issues, sometimes fairly complete. We have not investigated to see if such files have any monetary value. It would seem however that there ought to be many college libraries, and other reference centers where such files, even if not complete would be welcomed. Comments from members having had experience in these matters would be welcomed. Drop ye editor a line. R. R. B.

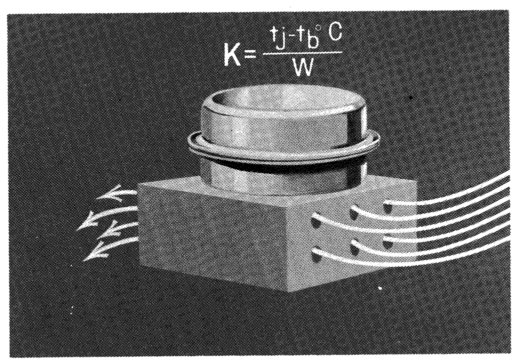


TUNG-SOL CONTROLS 'K' FACTOR

TO PRODUCE POWER TRANSISTORS THAT DELIVER FULL POWER

I_{CBO} is first measured at an elevated temperature. The transistor is then coupled, with silicone oil contact, to a copper block water-cooled to 25°C to provide an infinite heat sink. Power input is raised until I_{CBO} equals high temperature I_{CBO}. The temperature difference, divided by power, yields K in °C/watt.

This measure of a transistor's ability to remove heat from the junction is one of several significant criteria of Tung-Sol transistor quality and reliability.



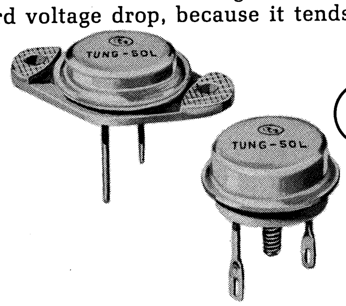
Maximum junction temperatures of 110°C, plus low K factors, enable Tung-Sol germanium power transistors to deliver full rated power under even the most adverse conditions. Design engineers can rely on full power performance because of the Tung-Sol policy of basing transistor design and specifications upon the most meaningful combinations of environmental and electrical tests.

K factor, or thermal resistance, is typical. Deceptively low K factors can be obtained by improper positioning of the external case temperature measuring device. Tung-Sol specifies junction-to-case—a more valid measure.

In monitoring junction temperature, Tung-Sol uses reverse leakage current (I_{CBO}), a parameter more meaningful to the design engineer than forward voltage drop, because it tends to reveal the effects of junction hot spots.

Maintaining low K factors (.5° C/watt maximum for the TO-36 configuration and .8° C/watt for the TO-3) is one of many ways Tung-Sol engineering builds an extra margin of power into transistors. In addition to 110°C junction temperatures, Tung-Sol power transistors have lower saturation voltage and higher breakdown voltages than ordinary transistors. Power transistor cases have copper-to-copper Cold Welds to prevent heat-caused contamination and damage and to assure maximum heat dissipation. Mounting surfaces are flat-ground to assure full heat sink contact.

All these quality features are available in both TO-3 and TO-36 configurations. Write for design information. Tung-Sol Electric Inc., Newark 4, New Jersey. TWX:NK193



TUNG-SOL® FULL POWER POWER TRANSISTORS

MEASUREMENTS'
"FAMOUS FIRSTS"

1939 MODEL 54 STANDARD SIGNAL GENERATOR—Frequency range of 100 Kc. to 20 Mc. The first commercial signal generator with built-in tuning motor.

MODEL 65-B STANDARD SIGNAL GENERATOR—This instrument replaced the Model 54 and incorporated many new features including an extended frequency range of 75 Kc. to 30 Mc.

1940 MODEL 58 UHF RADIO NOISE AND FIELD STRENGTH METER—With a frequency coverage from 15 Mc. to 150 Mc. This instrument filled a long wanted need for a field strength meter usable above 20 Mc.

MODEL 79-B PULSE GENERATOR—The first commercially-built pulse generator.

1941 MODEL 75 STANDARD SIGNAL GENERATOR—The first generator to meet the need for an instrument covering the I.F. and carrier ranges of high frequency receivers. Frequency range, 50 Mc. to 400 Mc.

1942 SPECIALIZED TEST EQUIPMENT FOR THE ARMED FORCES. WORLD WAR II.

1943 MODEL 84 STANDARD SIGNAL GENERATOR—A precision instrument in the frequency range from 300 Mc. to 1000 Mc. The first UHF signal generator to include a self-contained pulse modulator.

1944 MODEL 80 STANDARD SIGNAL GENERATOR—With an output metering system that was an innovation in the field of measuring equipment. This signal generator, with a frequency range of 2 Mc. to 400 Mc. replaced the Model 75 and has become a standard test instrument for many manufacturers of electronic equipment.

1945 MODEL 78-FM STANDARD SIGNAL GENERATOR—The first instrument to meet the demand for a moderately priced frequency modulated signal generator to cover the range of 86 Mc. to 108 Mc.

1946 MODEL 67 PEAK VOLTMETER—The first electronic peak voltmeter to be produced commercially. This new voltmeter overcame the limitations of copper oxide meters and electronic voltmeters of the r.m.s. type.

1947 MODEL 90 TELEVISION SIGNAL GENERATOR—The first commercial wide-band, wide-range standard signal generator ever developed to meet the most exacting standards required for high definition television use.

1948 MODEL 59 MEGACYCLE METER—The familiar grid-dip meter, but its new design, wide frequency coverage of 2.2 Mc. to 420 Mc. and many other important features make it the first commercial instrument of its type to be suitable for laboratory use.

1949 MODEL 82 STANDARD SIGNAL GENERATOR—Providing the extremely wide frequency coverage of 20 cycles to 50 megacycles. An improved mutual inductance type attenuator used in conjunction with the 80 Kc. to 50 Mc. oscillator is one of the many new features.

1950 MODEL 111 CRYSTAL CALIBRATOR—A calibrator that not only provides a test signal of crystal-controlled frequency but also has a self-contained receiver of 2 microwatts sensitivity.

1951 MODEL 31 INTERMODULATION METER—With completely self-contained test signal generator, analyzer, voltmeter and power supply. Model 31 aids in obtaining peak performance from audio systems, AM and FM receivers and transmitters.

1952 MODEL 84 TV STANDARD SIGNAL GENERATOR—With a frequency range of 300-1000 Mc., this versatile new instrument is the first of its kind designed for the UHF television field.

1953 MODEL 59-UHF MEGACYCLE METER—With a frequency range of 420 to 940 megacycles, the first grid-dip meter to cover this range in a single band and to provide laboratory instrument performance.

1954 FM STANDARD SIGNAL GENERATOR. Designed originally for Military service. The commercial Model 95 is engineered to meet the rigid test requirements imposed on modern high quality electronic instruments. It provides frequency coverage between 50 Mc. and 400 Mc.

1955 RADIO INTERFERENCE MEASURING SET. An aperiodic noise meter useful to 1000 Mc.

1956 MODEL 505 STANDARD TEST SET FOR TRANSISTORS. A versatile transistor test set which facilitates the measurement of static and dynamic transistor parameters.

1957 RADIO FIELD STRENGTH AND INTERFERENCE MEASURING SET. A tuned radio interference and field strength set covering the frequency range of 150 Mc. to 1000 Mc.

1958 MODEL 560-FM STANDARD SIGNAL GENERATOR—First successful FM Signal Generator using solid state modulator.

1959 MODEL 700 FREQUENCY METER—A completely new concept of frequency measurement. An instrument capable of direct and continuous reading to one cycle in 25-1000 Mc range.

1960 MODEL 139 TEST OSCILLATOR—A compact, versatile, and portable instrument for rapid and accurate alignment of I.F. circuits in all types of radio receivers.

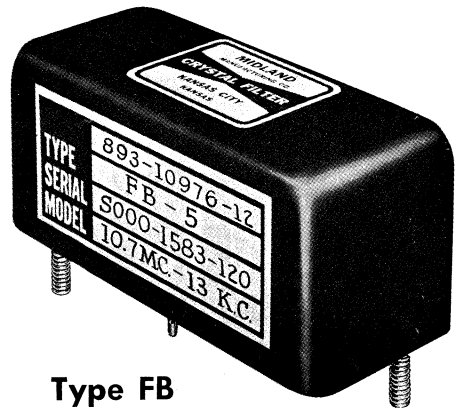
1961 MODEL 760 STANDARD FREQUENCY METER—An accurate, simple to operaate, direct read-out, portable instrument designed for servicing two-way mobile radio equipment.

MEASUREMENTS
A McGRAW-EDISON DIVISION
BOONTON • • NEW JERSEY • • U. S. A.

Delivered In Quantity...

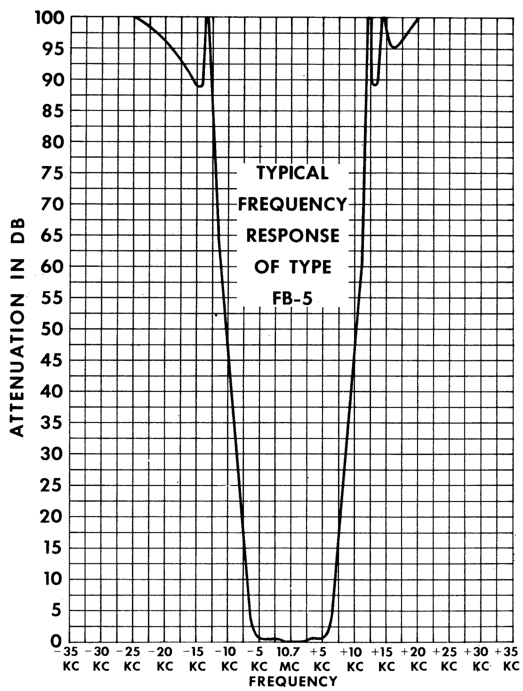
MINIATURE

Narrow Band-Pass Crystal Filters



Type FB

The Midland Type FB Series is a group of hermetically sealed, eight-crystal, narrow-band filters that provide band-widths in the range of 2 KC to 30 KC @ 6 db, with a center frequency of 10.7 MC. They are designed to operate in the environmental temperature range of −55°C to +90°C with an insertion loss of 4 db max. and an inband ripple of .8 db max. The Type FB narrow-band crystal filter is ideally suited for design in two-way communication systems, telemetry systems, electronic instrumentation equipment and other 10.7 megacycle applications where small fractional bandw dth filtering plus a high degree of selectivity and temperature stability is required. It can be used to best advantage in designing single-signal RF stages to give greater adjacent channel separation and performance reliability, in addition to conserving space and reducing material and manufacturing costs. Midland invites inquiries in assisting with any engineering problem where the use of crystals and crystal filters is proposed.



Specifications

	FB-5
Center Freq.*	10.7±375 CPS
BW @ 6 db Min.	13 KC
BW @ 60 db Max.	23 KC
60 db/6 db BWR Max.	1.8
BW @ 80 db Max.	26 KC
Ultimate Rejection Min.	105 db
Req. Source/Load Resistance (R_o)	1 K ohms
Inband Ripple Max.	.8 db
Insertion Loss Max.	4 db
BW @ 1 db Min.	10 KC

*Center freq is the arithmetic mean of the frequencies at 6 db.

Operating Temp. Range: −55°C to +90°C
Shock: 200 g
Vibration: 15 g to 2 KC
Max. Input Level: +10 dbm

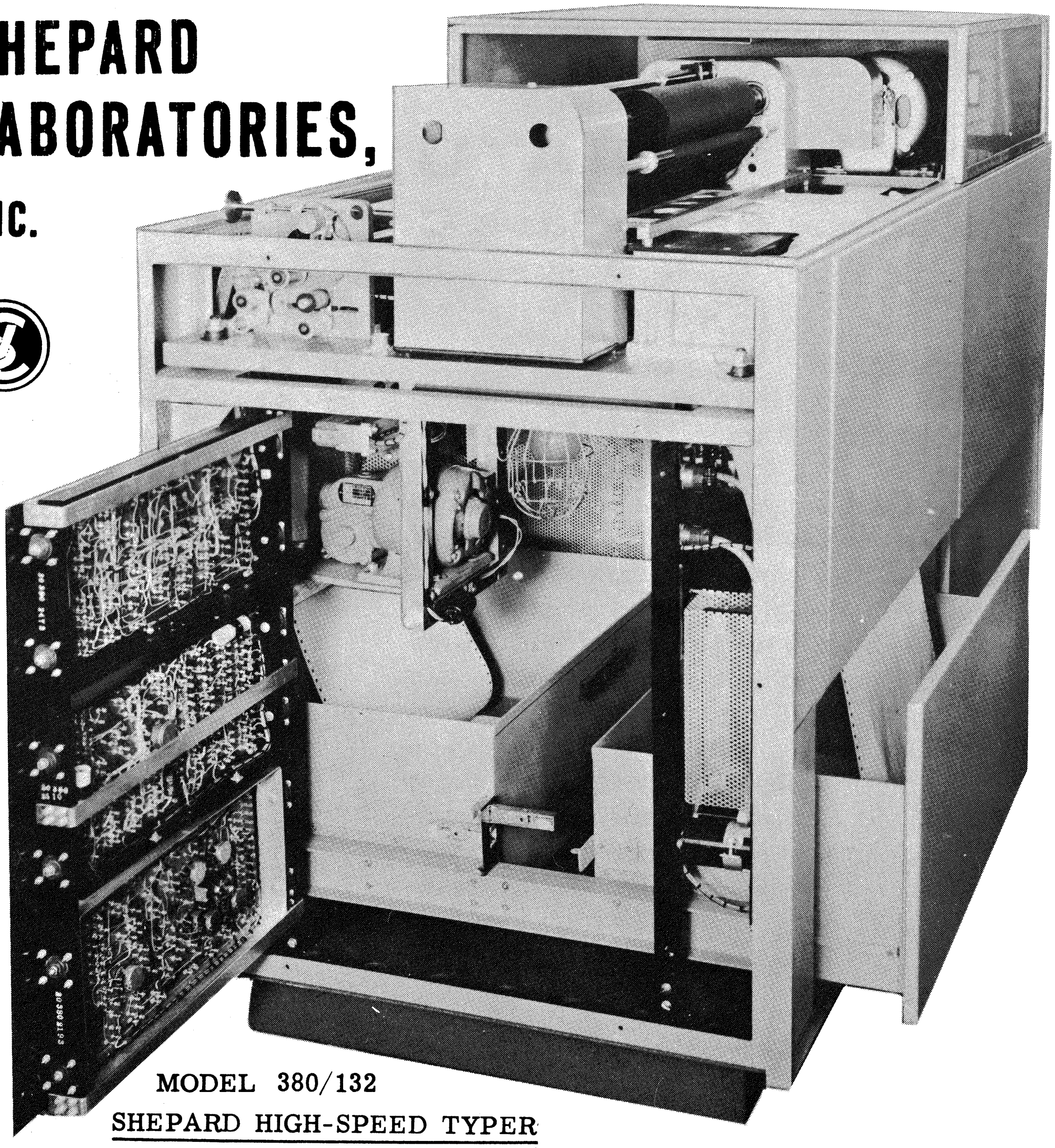
Midland MANUFACTURING COMPANY, Kansas City 15, Kansas

WORLD'S LARGEST PRODUCERS OF QUARTZ CRYSTALS

DIVISION PACIFIC INDUSTRIES INCORPORATED

Robert Finlay SALES COMPANY
MANUFACTURERS REPRESENTATIVE
RIDGEWOOD NEW JERSEY

SHEPARD LABORATORIES, INC.



MODEL 380/132

SHEPARD HIGH-SPEED TYPER

EDP PRINTERS

Shepard Laboratories of Summit, N. J. makes a variety of electronic on-the-fly typers ranging from specialized Minitypers capable of speeds up to 3,600 lines per minute to conventional alphanumeric typers with speeds up to 1,000 lines per minute. Printing is from a constantly revolving character drum embossed with up to 64 characters in each print column and with up to 50 columns in the Minityper and 190 columns in the conventional unit. All typers can be supplied with any choice of font.

Shepard typers are in use at commercial, industrial, and scientific, navigational and military installations such as the Army (OTAC) (MOBIDIC), the Navy (Polaris), The Atomic Energy Commission, RCA (BIZMAC), Bank of America (ERMA), universities, Sperry Rand, Sylvania, National Cash Register, and are in current use in England, France, Italy, Germany and the Far East.

SHEPARD LABORATORIES, INC. 480 MORRIS AVE. SUMMIT, NEW JERSEY

HUDSON WIRE COMPANY

makers of quality fine wire for over 60 years

FILM and FABRIC INSULATED MAGNET WIRES

Film Insulations: Enamel, EZ-Sol (nylon), Hud-Sol (polyurethane), Formvar, Siliclad (silicone), Nyform, Nypoly, Isonel & ML (220°C), each single or heavy. Sizes 14 to 56. Fabric Insulations: Celanese, Nylon, Silk, Cotton & Orlon, each single or double. All solid & tracer colors, Sizes AWG 20 and finer. Combinations of Film & Fabric insulations available.

SPECIALS: High Frequency Litzendraht. Voice Coil. Bifilar & Trifilar. Pig-Tail leads. Braided Wires. Loop Wires. Silver plated Nickel. Aluminum. Special Servings of Nylon & Celanese in colors.

MAGNET WIRE DIVISION

Winsted, Conn.
FRontier 9-3341
TWX WSTD 450

Cassopolis, Mich.
HIckory 5-2424
TWX CSPLS 07

SINGLE END and STRANDED BARE CONDUCTORS

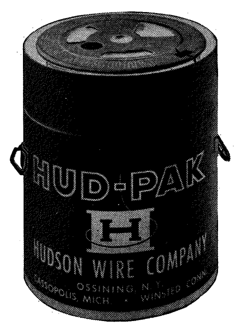
Copper (ETP & OFHC), Brasses, Bronzes, Other Copper Alloys, Aluminum, Silver, Zinc, Cadmium, Nickel, Tin, Lead, Monel, Stainless Steel, and Copper Coated Steel. Most metals available plated with Silver, Nickel, Tin (Hot Dip & Electro), Tin-Lead Alloys and Gold.

Concentric, Unilay, Bunched, and Rope Stranding, regular and reinforced, in finished Sizes AWG 4 to 32.

OSSINING DIVISION

Ossining, New York
WIlson 1-8500
TWX — OSING 964

FINE WIRE AT ITS FINEST



Available on Standard Wire Spools

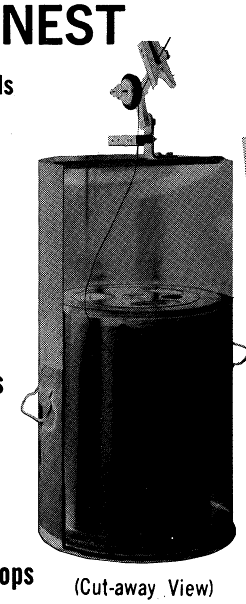
and on the Exclusive

HUD-PAK*

High Speed Wire Payoff Package

FEATURING:

- **High Speed Payoff in excess of 5000 ft. per min.**
- **Controllable Tensions.**
- **Large Payoff Packages of 50 and 120 Pounds.**
- **Instantaneous Starts and Stops**
- **Rugged Construction to Protect Wire in Use or Storage.**



(Cut-away View)

Phone or Write Hudson NOW for spec quotes and technical assistance

Member: Nat'l Security Industrial Assoc., Nat'l Electrical Manufacturers Assoc.

HUDSON WIRE COMPANY

Member: Nat'l Security Industrial Assoc.
Nat'l Electrical Manufacturers Assoc.

Sales Offices: Albany, N. Y.; Casselberry, Fla.; Chicago, Ill.; Cleveland, Ohio; Dallas, Texas; Knoxville, Tenn.; Los Angeles, Calif.; New York, N. Y.; Palo Alto, Calif.; Rochester, N. Y.; St. Louis, Mo.; South Whitley, Ind.; Syracuse, N. Y.; Waterbury, Conn.