The GBS Digital PIANO - TUNER

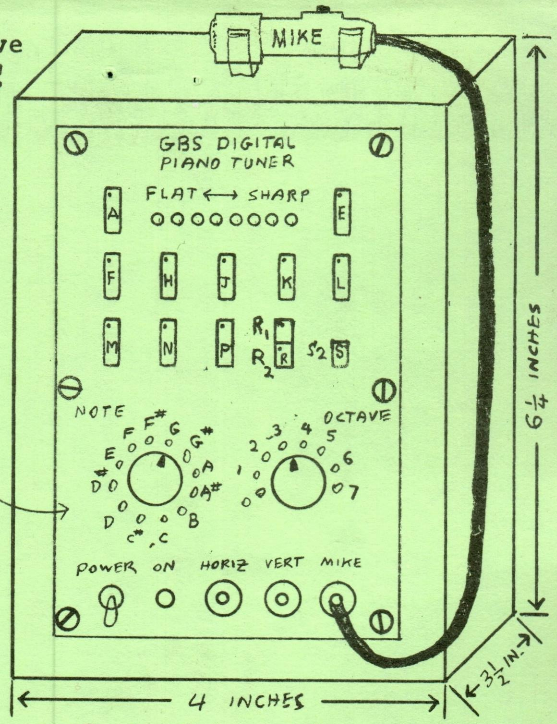
CONSTRUCTION INSTRUCTIONS - PLAN SET

Suitable for tuning all Band & Combo instruments!

Inexpensive and Novel!

Only 13 IC's !!

Perf. board size: 3½ X 6 inches



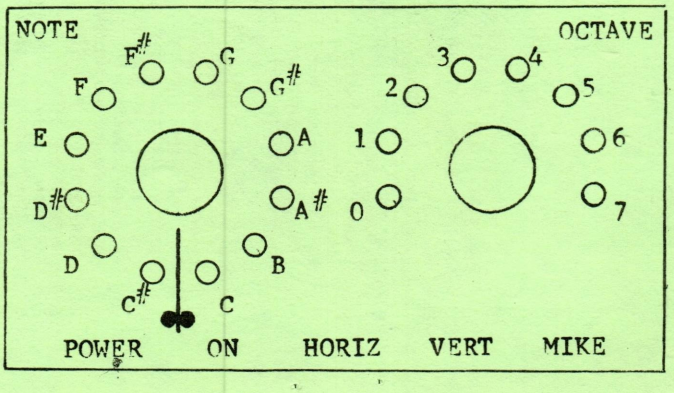
Typical Assembly

FEATURES AND SPECIFICATIONS

The GBS Digital PIANO TUNER is simple to use due to a modern new display technique that indicates tuning quality. The portable self-contained flashlight battery powered device offers optional oscilloscope outputs (both vertical and horizontal) for use with your oscilloscope if you have one (NOT REQUIRED) thus providing interesting scientific displays. The simple tuning operation enables the hobbyist reasonably interested in both music and electronics to tune pianos after reading our simple explanations and instructions regarding piano tuning and special tools (how to make or where to buy). The musical audio picked up by the inexpensive dynamic mike is amplified, analog processed, and fed to a special detector system that determines the precise relationship of the piano note to another accurate reference signal that is generated internally. A novel light emitting diode (LED) display bank, which is connected to this special detector, indicates when the musical note is flat, sharp, or in tune. Of course, this device may be used to tune very precisely musical instruments other than pianos also! The internally generated reference signals are very precisely fixed to the Equal Tempered Scale via the selector switches, one of which selects the Chromatic pitch while the other knob selects the octave. When the tuning device is finished and tested, you may be assured that the device is itself tuned correctly since all internal reference frequencies are fixed electronically and referenced to an internal crystal time base providing an excellent tuning reference. Only a couple of simple adjustments are required. The parts required to construct the device costs only about $40 if purchased from our suggested suppliers or similar sources. This cost may be easily made up by moonlighting if you care to!

LEGENDS USED ON THE GBS TUNER

GBS DIGITAL
PIANO TUNER
FLAT ⟷ SHARP



C O N S T R U C T I O N -- I N S T R U C T I O N S

Now you may build a genuine "EL-CHEAPO" piano tuning instrument that gives truly precise equal tempered scale tuning to any piano with a minimum of expense! There are four areas of difficulty in building this project:

1. The LED's are easily damaged by heat from your soldering iron. Use heat sinks fashioned from allegator clips or sharp nosed pliers while soldering. As a final touch you might put a dab of glue around the leads on the back of the breadboard to secure your lamps.
2. In the diode matrix construction, don't bend the leads on the diodes too short since heat damage from soldering might result. As you build this assembly, solder each diode quickly as it is installed rather than trying to solder all at one time. Be certain that you have all diodes installed in the right direction. The diodes are difficult to replace should you break it, heat damage it, or install it backwards. Test 'em before you solder them in place!
3. Build the electronic "Perf Board" circuit card entirely and test it before building and installing the case. This saves broken wires between the batteries and circuit and also aids in cutting the case mounting hole for the circuit board.
4. Check your parts clearances behind the circuit card before deciding how deep your case should be. Make it deeper if necessary to accommodate the parts if you have difficulty dressing the parts close to the back of the card.
5. Read carefully the "useful notes on construction" and the "Schematic reading" section since there are other hints of interest there also.

You might build the digital portion of the circuits first. This includes chips: A, E, F, H, J, K, L, M, N, P, power switch, the note selector switch, and one wafer of the octave selector switch (use the wafer nearest the knob end of the switch for the digital octave selector). Mount these parts and wire the Vcc and ground pins of these IC chips. Install the three decoupling capacitors on chips A, E, and P as shown in the schematics. Wiring a good crosshatch power grid system improves the noise immunity of the logic signals in your system. Now, wire the interconnecting signal wires starting at the top of the card with the LED's (note 1 above) and working down, winding up with the selector switches. See the "Digital Piano Tuner Construction Hints" drawing. The diode matrix assembly is shown in part. Note the connections shown are connected to IC chips P, N, & M (left side), and along the top, to the note selector switch poles C, B, A#, etc. and Vcc. One piece of perf board is used as a base for construction as shown. Push the anode lead of the top left diode through the hole and bend it over to the left. Leave about 1/8 inch of space between the diode body and card to protect the diode during soldering. Bend the top lead of the diode up towards the top. Now, install the "B" diode in the top row in the same fashion and solder the botton lead to the "C" diode. Pay close attention to installing the diode in the right direction. When done, check the matrix with an ohm meter if you have one, otherwise "eyeball" it very carefully. Now, solder the matrix assembly to the note selector using the top row of wires (you may have to extend some of them and install insulation. Once all the leads are soldered in place, the assembly will be stiff enough to stay in place so that no other mounting procedure is needed. Dress it close to the back of the switch as shown in "case sideview" drawing of the "typical assembly".

Now, test the digital circuits according to the following:

INITIAL DIGITAL TESTS:

1. Touch (momentarily) a wire from L-1 to Pin J-7. As the connection is made, all LED's should light. If some don't, it is most likely a bad LED damaged from soldering heat. When the connection is removed, no LED's should light. Try this for all 12 positions of the note selector and all 8 positions of the octave selector.

Do test 1 with a connection to pin J-3 from L-1 and obtain the pattern LDLDLDLD. L=LIT
Do test 1 with a connection to pin J-2 from L-1 and obtain the pattern DLLDDLLD. D=DARK
Do test 1 with a connection to pin J-6 from L-1 and obtain the pattern LLLDDDDL.
This completely tests all LED's and their respective connections. The MV-5082 LED is plastic and hence, is easily damaged by soldering heat.

2. If you have access to a frequency counter, check all frequencies generated against the note frequency chart on the next page.

FREQUENCIES IN HERTZ OF THE NOTES OF THE MUSICAL SCALE OF EQUAL TEMPERAMENT

OCTAVE NO.	ZERO	ONE	TWO	THREE	FOUR	FIVE	SIX	SEVEN	EIGHT	NINE	TEN
C+1 =	32.703195	65.406391	130.81278	261.62556	523.25113	1046.5022	2093.0045	4186.0090	8372.0181	16744.036	33488.072
B =	30.867706	61.735412	123.47082	246.94165	493.88330	987.7666	1975.5332	3951.0664	7902.1326	15804.265	31608.531
A-SHARP=	29.135235	58.270470	116.54094	233.08188	466.16376	932.3275	1864.6550	3729.3100	7458.6201	14917.240	29834.480
A =	27.500000	55.000000	110.00000	220.00000	440.00000	880.0000	1760.0000	3520.0000	7040.0000	14080.000	28160.000
G-SHARP=	25.956543	51.913087	103.82617	207.65234	415.30469	830.6093	1661.2187	3322.4375	6644.8751	13289.750	26579.500
G =	24.499714	48.999429	97.99885	195.99771	391.99543	783.9908	1567.9817	3135.9634	6271.9269	12543.853	25087.707
F-SHARP=	23.124651	46.249302	92.49860	184.99721	369.99442	739.9888	1479.9776	2959.9553	5919.9107	11839.821	23679.643
F =	21.826764	43.653528	87.30705	174.61411	349.22823	698.4564	1396.9129	2793.8258	5587.6516	11175.303	22350.606
E =	20.601722	41.203444	82.40688	164.81377	329.62755	659.2551	1318.5102	2637.0204	5274.0408	10548.081	21096.163
D-SHARP=	19.445436	38.890872	77.78174	155.56349	311.12695	622.2539	1244.5079	2489.0158	4978.0317	9956.063	19912.126
D =	18.354047	36.708095	73.41619	146.83238	293.66476	587.3295	1174.6590	2349.3181	4698.6362	9397.272	18794.545
C-SHARP=	17.323914	34.647828	69.29565	138.59131	277.18262	554.3652	1108.7305	2217.4610	4434.9220	8869.844	17739.688

Measure these frequencies at E-9. You won't get the exact frequencies shown in the table. But, you should obtain readings that agree with the table to an accuracy of about 0.1% or better. The table is presented to an accuracy much better than 0.1% just for interest and completeness. If you don't have a frequency counter, then carefully check your wiring, especially the diode matrix since a mistake here will cause your instrument to be out of tune for the particular note affected.

Now, build the analog circuits comprising the 741 OP-AMPS (R_1, R_2, and S_2), the two rear wafers of the octave selector switch (build up the capacitors right on the switch in a "ring" formation around the switch, making note that one lead of each capacitor gets tied together with all other capacitors). Wire Vcc of the op-amps to chip L-pin #14, -V of the op-amps to the power switch and the common ground connections to chip L-pin #7 also. Ground the three input output jacks to chip L-pin #7 also. Mount the BALLANCE ADJUST pot right under OP-AMP R_1.

Now that completes the electrical assembly unless you elect to use the "AC" plug in power supply shown in the "Dual Supply Circuits" drawing. The LM-309K IC looks like a power transistor and may be mounted directly to the case for heat sinking without insulation since the case is ground. No heat sink grease is required since the disipation is low. Build the rest of the circuit in place of the batteries. You may want to use the "AC" supply if you plan to tune many pianos with your tuner. However, the tuner draws only about as much power as a flashlight and for only a dollars' worth of batteries you get alot of convenience. This is cheap relative to the price you might charge or pay to have a piano tuned (25.00). The "A" cells will last about eight times as long as the "D" cells. Good practice dictates however, that you toggle your power off during set-up from string to string to conserve your battery power yielding about a days' worth of use. You should be able to tune two or three pianos a day!

You may want to test the tuner by whistling or humming a note into the tuner with the note selector set to "C" and the octave selector set to "4". Try to whistle up or down in pitch gradually until you see a stationary pattern in the display. That's all there is to it! You may adjust the BALLANCE ADJUST pot while looking at the display. Find the point where the display just lights to medium intensity. This adjustment is not critical but if adjusted properly your instrument will be most sensitive to the audio produced by the piano. Try not to make any sounds while adjusting the pot, but leave the microphone connected.

CIRCUIT OPERATION AND DESCRIPTION

Now, inspecting the "Construction Hints" drawing again where a tuning system block diagram is presented showing the basic functions within this little tuning system. We have four basic functions. An audio processor and a frequency generator each provide a squarewave TTL compatible signal to the tuning detector which determines the relative frequency error therebetween and sends the results to the display system comprising eight LED's arranged in a row providing an apparent motional or stationary pattern which indicates tuning quality.

The frequency generator is crystal controlled and provides a reference frequency (which is the same frequency as the note you are tuning) to the detector circuit. This reference frequency may be monitored at the Horizontal output jack with a simple audio amplifier and speaker arrangement for technicians that may want to use ears as an additional aid in tuning. You may want to install a simple amplifier/speaker in your tuner, however, this is left to the hobbyist experimenter. Obviously this might interfere with the microphone pick-up, however, you may use each, one at a time. Now, this detector circuit "looks" for the same frequency as the generator reference and converts any difference to "useful data" in a "format" that enables your eyes to see what a seasoned piano technician might do with and hear with his/her ears. Anyone inexperienced with musical tuning will usually find it difficult to hear any difference. But, this difference sounds as a beat frequency audible to trained musicians, etc. that can readily hear this difference.

The Frequency Generator drawing shows this simple circuit. TTL type (7400) logic is employed in this project due to the high frequencies (10MHz) which are required to yield the high degree of accuracy of this great tuning device. None of the lower power devices such as RTL, DTL, MOS, or LOW POWER TTL would work at this precision and save power. A crystal oscillator made from 3 Nand gates in a 7400 IC, chip "A" provides the reference to the system. The 10 MHz squarewave signal drives the frequency synthesizer counter circuit (binary counter chips M,N, & P) which count down to 000 at which time nand gate (A-11) goes low momentarily (about 100 ns) until the flip-flop (F-5) goes low following the next rising edge of the 10 MHz clock present at pin F-3. This presets the binary counters (M,N, & P) with a numerical value which has been calculated so that a certain period of time is required for the counter to count down from this value to zero (000). This time period repeats at the frequency of the seventh octave on the piano (highest octave of notes) multiplied by eight to a tolerance of about 0.1%! This frequency is divided down seven octaves by the seven bit counter (chips P,F,&H). A specific tap is selected for presentation to the detector by the octave selector switch. The NOTE selector grounds a row of diodes which in turn grounds selected inputs to the counter chips M,N,&P; leaving other inputs high. You should verify these inputs to the counter for each of the 12 positions of the selector switch with a meter to verify that the matrix is functioning properly thus assuring that the frequencies are correct. The diode matrix thus "programs" the counters according to the selector switch position for the desired note frequency. The counters (P, F, &H) produce eight octave frequencies O_7 through O_0 which connect to the octave selector switch shown in the "audio processor, tuning detector, and display system" drawing.

In this drawing, the single selected octave output via the octave selector switch issues to the clock of a shift register 74164, chip L-pin #8, the reference frequency input of the detector. The musical note from the microphone is amplified and processed by the three 741 op-amp circuits and enters the shift register at the serial data input pin L-1. This input data representing the input piano note (essentially an averaged squarewave for clean sounding piano strings with a minimum of harmonics) is shifted down the 8 bit shift register once for each clock period input which is the reference frequency from the octave selector switch. The 8 output lines (A-H) are connected to the inputs of a pair of 4 bit latch circuits, chips K & E. These 8 input signals are "stored" into the latch circuits once every eight cycles of the reference frequency. The latch outputs drive the LED's yielding a visable display of the piano note tuning quality. The reference frequency from the selector switch and present at the shift register clock pin L-8 is divided by eight through the counter chip J-6 which provides the "store command" signal to the latch circuits and horizontal output jack. Thus, for every 8 shifts of the shift registers chip L, the 8 outputs are latched into storage registers K & E for non-blinking display via the LED's which comprise the display bank.

T H E   S H O P P I N G   L I S T

The shopping list is offered as a guide only, as a check off to aid in buying the required parts. It is not a descriptive list since the parts have been described in the drawings and texts. You should shop around for your parts to obtain the lowest price. Some suppliers are suggested elsewhere in the PLANS, but you may find other suppliers as well. It is really worth checking prices and availability before buying since the potential savings are great. Do not however, use untested bargains because the project will not work if you have installed a bad part and it may be difficult to locate the bad part especially if you have multiple bad parts in the same project. Hence you should use only first line quality parts that are easily obtained from the suggested suppliers or your local parts store in the larger cities.

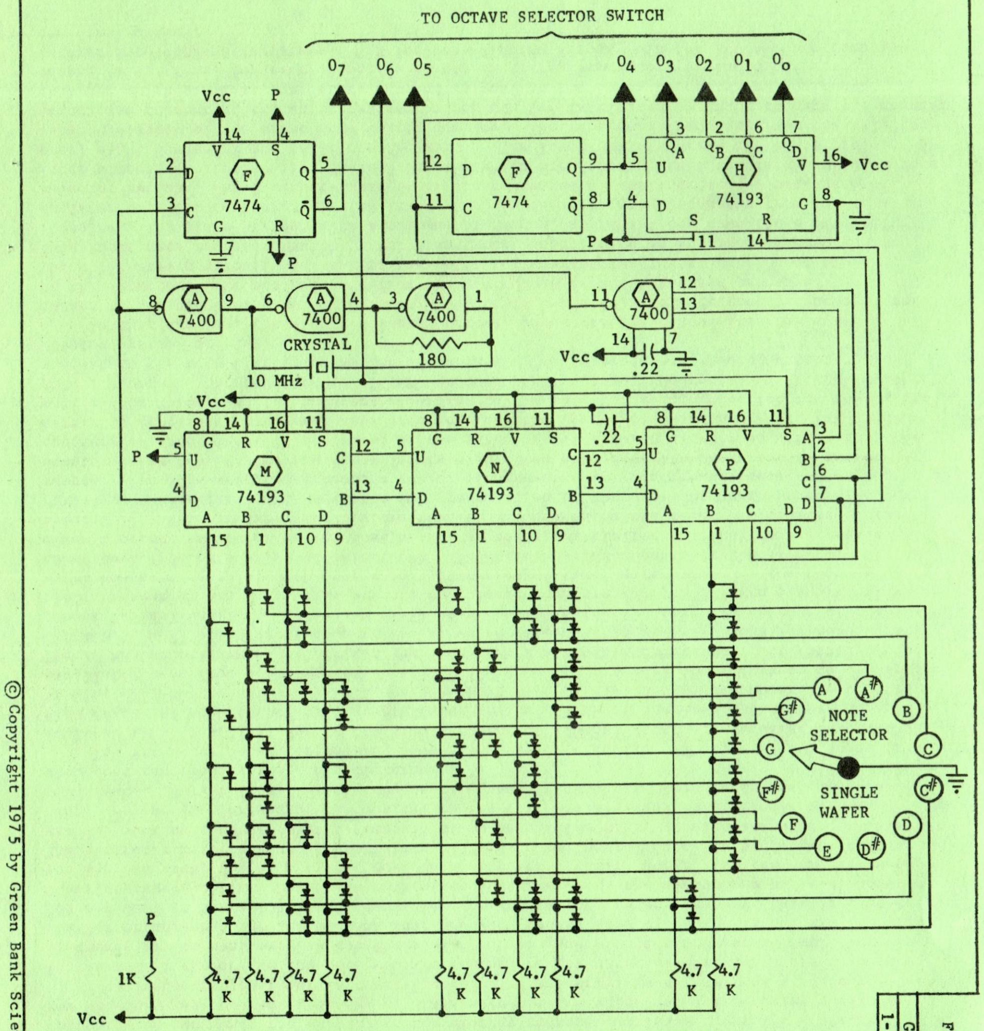
1	7400 nand gate IC
1	7474 dual flip flop IC
1	74164 shift register IC
2	74175 quad latch IC
5	74193 binary counter IC
3	741 operational amplifier IC
66	1N914 Minature silicon diode
8	MV-5082 LED or similar (most any LED will work)
2	.0003 mfd ceramic disk capacitor
2	.00068mfd ceramic disk capacitor
2	.0012 mfd ceramic disk capacitor
2	.0022 mfd ceramic disk capacitor
2	.005 mfd ceramic disk capacitor
2	.01 mfd ceramic disk capacitor
2	.02 mfd ceramic disk capacitor
2	.05 mfd ceramic disk capacitor
3	.22 mfd ceramic disk capacitor
4	50 mfd 15vdc electrolytic

1 Crystal ordered as follows:
From: JAN CRYSTALS
2400 Crystal Drive
Fort Myers, Florida
33901

Send quantity of one:
Fundamental Mode Crystal
"AT-CUT" high stability
10.000MHz; .005% Tol.;
HC18/U with wire leads,
Load Capacity: 32Pf.;
Non Oven; Series Resonance.
$3.00 each Plus 25¢ postage.

1	180 ohm resistor
8	270 ohm resistor
1	1K ohm resistor
1	1.5Kohm resistor
1	2.2Kohm resistor
11	4.7Kohm resistor
2	10K ohm resistor
1	51K ohm resistor
2	470Kohm resistor
1	10K minature potentiometer
1	DPST minature toggle switch
1	single wafer 12 position rotary switch
1	tripple wafer 12 position rotary switch
3	audio type phono jacks and plugs
4	Eveready #915 Battery "A" cell or equiv.
4	Eveready #950 Battery "C" cell or equiv.
1	3½ X 6 inch Perf. Board, Vector Type 169P44-062 or equiv. Also piece: 1.125" X 1.625" (diodes)
1	Microphone, dynamic type with output impedance of about 4K ohms to about 50K ohms (not critical as long as you are in about this range of values for the mike impedance). You should be able to locate the inexpensive (5-10 dollars) type used with most cheap cassette tape recorders. Just make sure that it is a DYNAMIC type Mike.

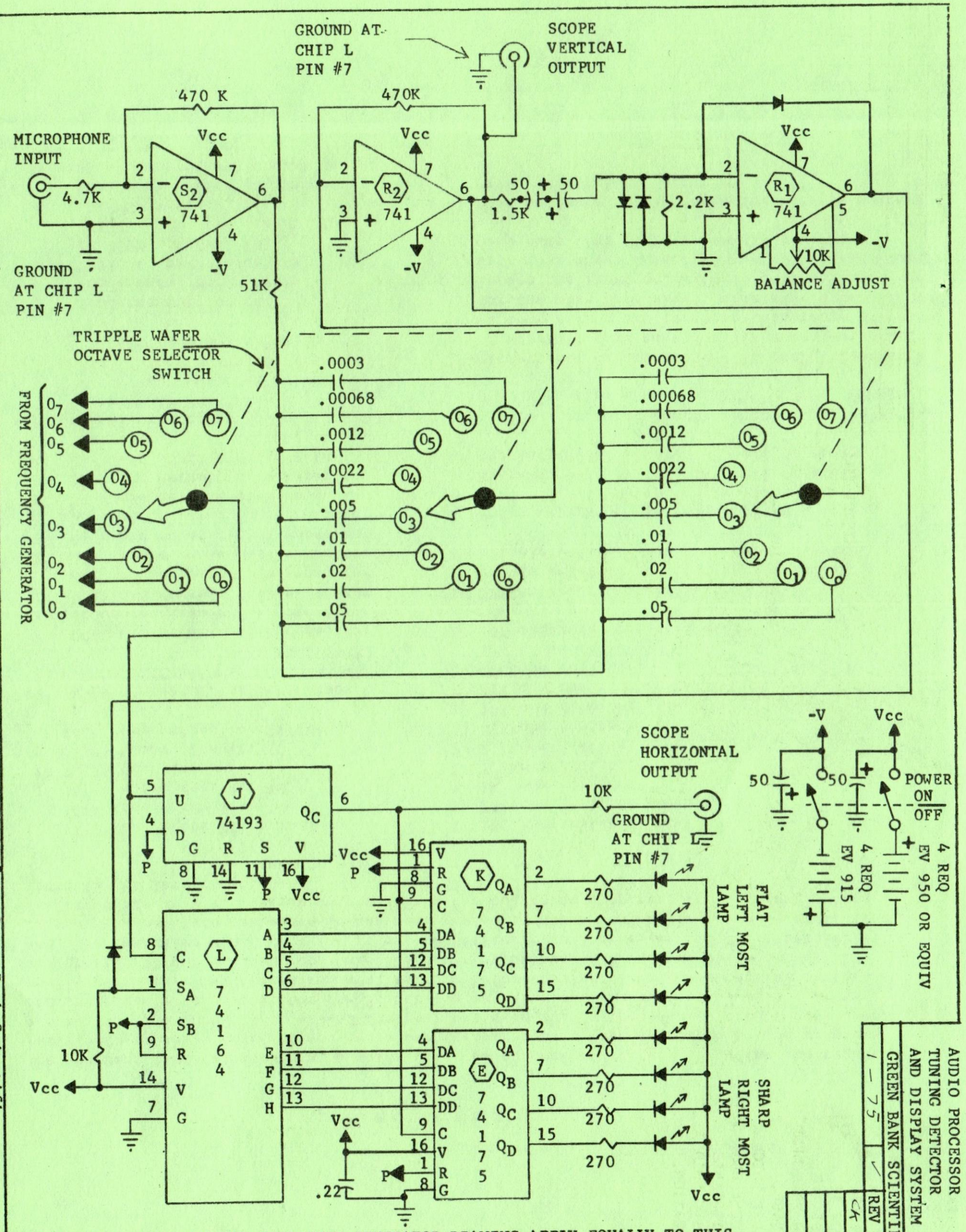
Misc hardware, knobs, sockets, battery holders, case, rubber feet, etc.



UNLESS OTHERWISE NOTED THIS APPLIES TO ALL DRAWINGS IN THIS PROJECT:

ALL RESISTORS IN OHMS, ¼ WATT 5%
ALL CAPACITORS IN MICROFARADS, 16 VDC
ALL DIODES ARE SILICON 1N914 MINATURE
ALL POINTS MARKED Vcc ARE TIED TOGETHER
ALL POINTS MARKED ⏚ ARE TIED TOGETHER
ALL POINTS MARKED -V ARE TIED TOGETHER
ALL POINTS MARKED P ARE TIED TOGETHER
ALL REQUIRED DECOUPLING CAPACITORS ARE SHOWN ON THESE DRAWINGS

FREQUENCY GENERATOR
GREEN BANK SCIENTIFIC
1-75 | x | REV | AUT



NOTE: THE NOTES ON THE FREQUENCY GENERATOR DRAWING APPLY EQUALLY TO THIS DRAWING AS WELL. P's, Vcc, ETC. CONNECT BETWEEN CIRCUITS OF BOTH DRAWINGS

AUDIO PROCESSOR TUNING DETECTOR AND DISPLAY SYSTEM
GREEN BANK SCIENTIFIC
1-75 | REV | AUT

CIRCUIT CONSTRUCTION AND PACKAGING

It is considered most economical to build GBS projects on any perforated board that will mount DIP IC's directly into the board, such as vector integrated circuit board type 64P44-062 available from Allied Radio Corporation stock No. 977-1212 at a cost of $2.57. This board comes 6½ X 4½ inches with holes 1/10 inch apart to mount IC's. If it is larger than required, a piece can be cut off saving the rest for other projects. The circuit schematics show the suggested IC locations by the use of letter designations in the following sequence: A,B,C,D,E,F,H,J,K,L,M,N,P,R,S,T,U,V,W,X,Y,Z,AA,BB,CC,DD,EE,FF,ETC. The IC's are pushed into one side of the board designated as the front or component side. The locations are then lettered starting with "A" in the upper left corner and reading right in rows and down as shown:

```
                                  A B C D    A B C
 A B     A B C    A B C D   A B C   E F H J    D E F        Naturally only one
 C D     D E F    E F H J   D E F   K L M N    H J K        system is used for
         H J K    K L M N   H J K   P R S T    L M N        a given board.
      9IC-EXAM              L M N              P R S  etc.
```

The quantity of IC's to a row and the quantity of rows is shown in the typical assembly drawing. Pin #1 of each IC (designated in the IC with a notch or small depression near it) is oriented to the upper left corner of the card when viewed from the front side. Not all IC locations will contain an IC, but some may contain discrete parts such as resistors, diodes, transistors, inductors, capacitors, switches, lights, etc. In the schematics this is shown with a circled letter ⟨A⟩ , ⟨B⟩ , ⟨C⟩ , etc. near the parts that are mounted in location designated by the letter. Finally, these boards, if more than one will have a number so that any pin on any IC on any board in the project can be located by a simple sequence of numbers and letters. For example pin #10 of IC-K on board #3 is called out as 3K10. GBS provides a wire list using this alphanumeric notation for multiboard projects in which wires run from one board to another. This allows us to break up a large one board project into many smaller boards that are easy to package into a case.

Start wiring the circuit with the power supply connections. The best wiring procedure is to use #26 wire that is of the tin or solder plated bus wire variety and make a small wrap around the first appropriate pin and solder. Do not cut the wire yet but measure the distance to the next pin as shown in the schematic and cut a piece of thin wall teflon tubing (Alpha Wire Corp. type TFT-200) to this distance length and slip it over the bare bus wire. Now wrap and solder to the next pin. Do not cut, but continue until all of the interconnecting connections are made to a specific node group then cut the wire and start the next node group. In projects using 7400 IC's the power supply MUST be decoupled with several small ceramic capacitors of approximately .2mfd value such as LAFAYETTE RADIO stock No. 33P69097 and one 100mfd. capacitor electrolytic such as LAFAYETTE STOCK NO. 34P85687. The quantity of ceramic capacitors used must be about ¼ the number of IC's used in the project. For example, if there are 12 IC's used, then approximately 3 ceramics should be spread evenly around the board connected to the power supply and ground pins of 3 7400 IC's. The capacitors must not be bunched but placed on IC's that are far apart. For the 9 IC example above the capacitors would be placed on IC-A, IC-G, and IC-J. For analog circuits such as audio circuits using OP-AMPS or discrete transistors only it is only necessary to use the Electrolytic capacitor.

The box enclosure that contains the circuit and batteries may be made of wood, plastic or aluminum sheet or bought or found from products boxes, just whatever suits the builder. But try to build the project as small as possible since this is what is so attractive about IC projects. All wires must be kept less than ten inches in length---very important!

When you install wires, it is a good idea to use a red pencil and mark over each wire on the schematic as you install it in the circuit as a check off and to help prevent mistakes. This may also be done for discrete parts such as resistors, capacitors, inductors, and diodes.

SOME USEFUL NOTES ON ASSEMBLY:

Use care when soldering integrated circuits (IC). Use sockets and insert IC's after circuit has been assembled to insure that the IC's are not damaged during the soldering procedure.

Always "ring-out" your circuit after all soldering has been completed but before inserting IC's in sockets. Use a good ohm-meter or sensitive low power, low voltage continuity checker for this purpose. This little precaution will save alot of heart ache & misery since a simple mistake can wipe out all semiconductors and IC's in your project which can happen in an instant and can be expensive not to mention the fact that a lot of time may have been invested in aquiring the parts.

Pencil in the pin numbers in the schematic for the IC's not so numbered for the ones that you have on hand. The pin numbers for various IC's are given in the upper corner of the schematic drawing.

Generally you are expected to know how to read schematics to assemble GBS projects but these notes may help the beginner:

Layout the circuit on a breadboard similar to the schematic layout.

Keep the leads as short as possible.

No other placement precautions are necessary except if noted in drawings.

A lot of free aid is available for the asking. If you are new at reading schematics you may get help from sales people at the local electronic parts distributor store where you may buy parts to build a project. Try Lafayette or Radio Shack associate stores.

Be sure to consult the advertisement sections in the back of magazines such as Popular Electronics, Audio, or Electronics World/Radio Electronics which always have ad's offering very good prices on components which are suitable for GBS projects.

GBS will endeavor to answer any questions you may have concerning GBS projects if you will state as much as you can in as clear a fashion as you can the trouble you are experiencing and send a self addressed stamped envelope to the address shown below we will try to clear your problem.

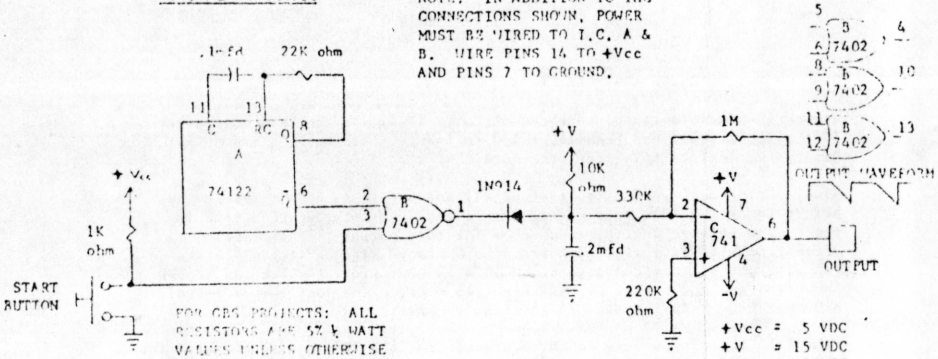
Green Bank Scientific
Customer Service Dept
Post Office Box 100
Green Bank, WVa. 24944

Never use unused pins on IC's as "tie-points" for other connections since these unused pins may be connected internally to some functions of the IC.

GBS endeavors to "pack" as much knowledge and info as possible into as small a space as possible. Only necessary facts are given. This saves materials and postage which enables you to obtain a novel idea for your hobby through mail order at a reasonable price for low production items.

TYPICAL SCHEMATIC

NOTE: IN ADDITION TO THE CONNECTIONS SHOWN, POWER MUST BE WIRED TO I.C. A & B. WIRE PINS 14 TO +Vcc AND PINS 7 TO GROUND.



FOR GBS PROJECTS: ALL RESISTORS ARE 5% ¼ WATT VALUES UNLESS OTHERWISE NOTED. CAPACITOR VOLTAGE RATINGS ARE 50 VOLTS OR LESS.

+Vcc = 5 VDC
+V = 15 VDC
−V = -15 VDC

A REFRESHER IN SCHEMATIC READING FOR BEGINNERS

The schematic above is given as an example for a review of schematic reading technique for those who may need it. All connections are shown except for some power connections which are left out for simplicity. A note calls out these connections as +Vcc must be wired to pin 14 on IC-A and IC-B. Wire ground also by tying the common terminals of the power supplies together and to ground. A note calls out the values of the power supplies as being 15 volts for plus V and minus 15 volts for minus V, Etc. These may vary for different projects.

A start button is wired between ground and to Vcc through a resistor of 1K ohm value. A wire is also connected from the start button to pin number 3 of IC-B. A capacitor of .1mfd value is connected from pin 11 to pin 13 of IC-A. A resistor of 22K ohm value is connected from pin 8 to pin 13 of IC-A. A diode has at least one colored stripe painted around one end and the wire coming out of this end is connected to pin 1 of IC-B. Note in the schematic that the type 1N914 diode has a line and arrow as its symbol. The arrow points toward the stripe and lead that is connected to pin 1. The other end of the diode is connected to the junction of two other resistors and a capacitor. The other end of the .2mfd capacitor is connected to ground. The rest of the connections in the schematic may be made following similar procedures.

IC-A is a type 74122 which is a one-shot connected as an oscillator circuit. IC-B is a 7402 NOR gate. Only one section is used--the other 3 sections are shown in the spares. A 741 type OP-AMP is IC-C. You will find prefixes and suffixes such SN7402N, 741EN, etc. Any I.C. that has the proper sequence of numbers 7402 may be used for IC-B. The rule applies to other I.C.'s as well unless otherwise noted in the schematics. The prefixes and suffixes generally refer to case and manufacturer identifiers and don't effect electrical performance of the I.C. The IC-C is a 741 OP-AMP with pin 7 connected to the 15 volt supply. The other side of the supply is connected to ground. Pin 4 is connected to -15 volts with the other side of the supply connected to ground so that 30 volts appears accross pins 7 and 4 of IC-C. The output of the circuit generates the waveform as shown when the start button is pushed. Gate "B" allows the square wave signal from I.C. monostable "A" be passed through to the diode which discharges the .2mfd capacitor with each cycle of the monostable output. This causes a changing voltage to appear accross the capacitor which is amplified by a factor of 3 by the 741 circuit.

Green Bank Scientific hopes this little example will help you read the universal language of schematics used by electronics engineers, technicians, and hobbyists alike, if you don't already know how. If you still have trouble after reading the example, you may obtain help from places noted elsewhere in these plans or free from the library. Check a good book out of the library. It's one of the few things that is still left free to enjoy!

Wire lists and parts are not usually presented in GBS projects since this is considered redundant data which only raises costs. The data is clearly available from the schematics. Parts for GBS projects may be obtained from the following companies: (ask for catalog)

Poly Paks	Solid State Systems, Inc.	Solid State Sales	Allied/Radio Shack
Box 942	Box 773	Box 74	2725 W. 7th Street
Lynnfield, Mass. 01940	Columbia, Mo. 65201	Somerville, Mass. 02143	Ft. Worth Tex. 76107

Prices vary for different components so try all of the above suppliers if you decide to use mailorder to obtain your parts. We believe that the above supliers offer good service but GBS cannot accept responsibility for the service of any suggested suppliers.

A very nice large free catalog is available from Lafayette. If you don't have it, get it. It is highly recomended. Every hobbyist should be familar. The full address is:

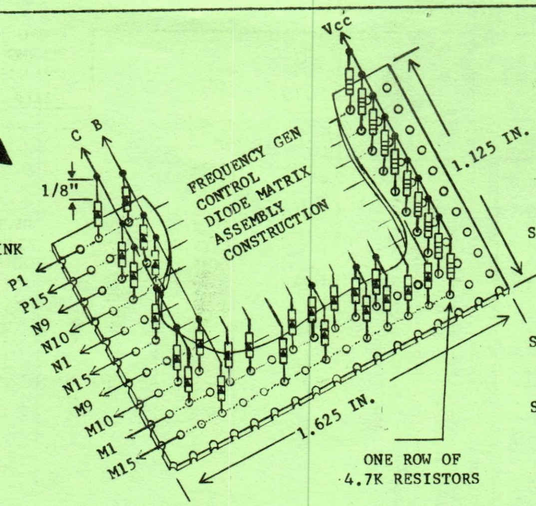
Lafayette Radio Electronics
Mail order and sales center
111 Jericho Turnpike
Syosset, L.I., New York 11791

Also, a very good catalog of a general scientific nature is available from:

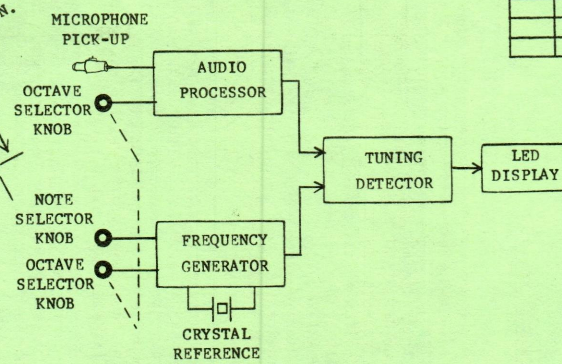
Edmond Scientific Company
635 Edscorp Building
Barrington, New Jersey 08007

DIGITAL PIANO TUNER CONSTRUCTION HINTS			
GREEN BANK SCIENTIFIC			
1-75	x	REV	AUTH

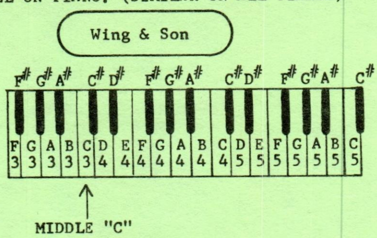
IMPORTANT!
DO NOT BEND AND SOLDER DIODE LEADS TOO CLOSE TO BODY ALLOW AT LEAST 1/8 INCH FROM BEND TO CASE. SOLDER QUICKLY AND USE HEAT SINK IF POSSIBLE DURING SOLDER OPERATION.



TUNING SYSTEM BLOCK DIAGRAM

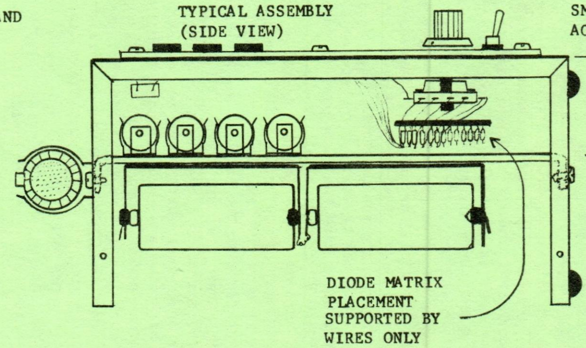


RELATIVE PLACEMENT OF MIDDLE "C" (C_3 = 261.6 Hz) AND HEADER LABEL ON PIANO. (SIMILAR ON ALL PIANOS)

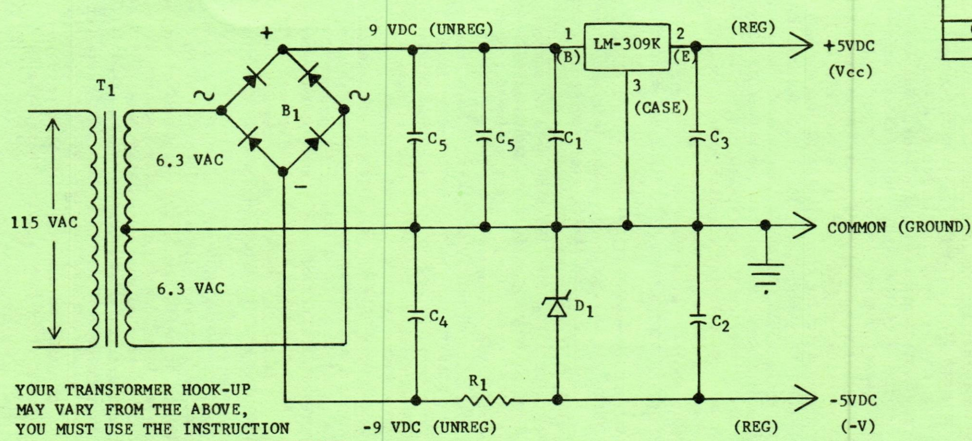


TYPICAL ASSEMBLY (SIDE VIEW)

SMALLER THAN ACTUAL SIZE



DUAL SUPPLY CIRCUITS			
GREEN BANK SCIENTIFIC			
1-75	x	REV	AUTH



NOTE: YOUR TRANSFORMER HOOK-UP MAY VARY FROM THE ABOVE, YOU MUST USE THE INSTRUCTION SHEET PACKED WITH YOUR TRANSFORMER

COMPONENTS

- T_1 ESSEX (STANCOR) P-6375 TRANSFORMER OR EQUIV: LAFAYETTE CAT. #33 E 84815, 115 VAC PRIMARY, 12.6VAC SECONDARY, 1AMP
- B_1 MOTOROLA HEP 176 FULL WAVE BRIDGE RECTIFIER -- 200 PIV, 1 AMP. OR EQUIV.
- C_1 .22 MICROFARAD, 50 VDC CERAMIC CAPACITOR
- C_2 10 MICROFARAD, 15 VDC ELECTROLYTIC CAPACITOR
- C_3 100 MICROFARAD, 15 VDC ELECTROLYTIC CAPACITOR
- C_4 500 MICROFARAD, 15 VDC ELECTROLYTIC CAPACITOR
- C_5 2000 MICROFARAD, 15 VDC ELECTROLYTIC CAPACITOR
- R_1 30 OHM, ½ WATT RESISTOR
- D_1 5.1 VDC, 1 WATT ZENER DIODE
- VOLTAGE REGULATOR MODULE IC TYPE LM-309K IN TO-3 TRANSISTOR CASE (THE CASE IS SPECIFIED BY THE "K" AFTER #309)

ALSO A SUITABLE CASE, LINE CORD & PLUG, AND HARDWARE

NOTES: THIS POWER SUPPLY MAY BE USED TO REPLACE THE BATTERIES SUGGESTED IN THE PLANS. YOU MAY WANT TO SEPARATE THE POWER SUPPLY FROM YOUR SYSTEM SINCE AC HUM PICKUP FROM THE POWER SUPPLY MAY IMPAIR THE OPERATION OF THE DEVICE IF IT IS INSTALLED WITHIN THE SAME METAL CASE WITH THE ANALOG PARTS OF THE SYSTEM.

NOW SOME TUNING BASICS:

A respectable piano tuner even at the hobbyist level, must know about such things as tuning hammers, wedges, and mutes; tuning pins, strings, unisons, beat notes, octaves, and visual motional pattern tuning aids such as the GBS Digital PIANO TUNER. These things are really simple to understand and will be explained here.

A tuning hammer is the wrench used by the piano tuner to turn the tuning pins found along the top of the insides of the piano. The strings are wound around these pins and held stretched tightly so that by turning a pin, you can either tighten or loosen the string to make the note produced by the string more sharp or more flat. The tuning hammer (wrench) has a long handle making the pin easy to turn. The head of this tool is similar to a socket wrench which fits either square pins or star shaped pins. Most pianos use square pins. You may save yourself the expense of buying a tuning hammer by using a quarter inch square socket wrench that fits stove bolts. In using this arrangement however one should hold the wrench firmly on the tuning pins as they are turned since any slipping may damage the pins. Also, the tuning hammer has a longer handle than the usual socket wrench so that it is more difficult to turn the pins with a socket wrench arrangement than a tuning hammer. Tuning hammers may be purchased from Freeport Music, Inc.; 455 Route 110, Melville, N.Y.; 11746. Order a #8024 "Piano Tuning Hammer" for star shaped tuning pins and a #8025 "Piano Tuning Hammer" for square pins. They cost $6.97 each in 1974 dollars. For current prices ask for their free catalog.

Tuning wedges and mutes may be made by cutting large pencil erasers to fit between the strings of the piano. You may obtain a professional set including also the hammer for $17.50 (1974 dollars) by ordering the "Basic Tuning Kit" from the above mentioned company.

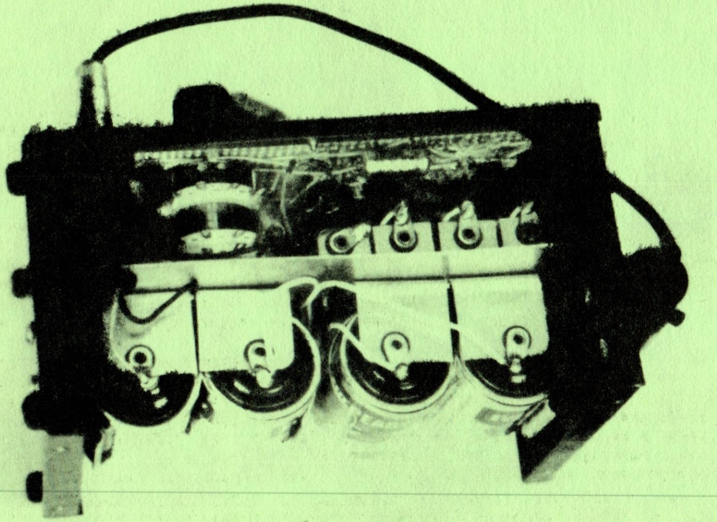
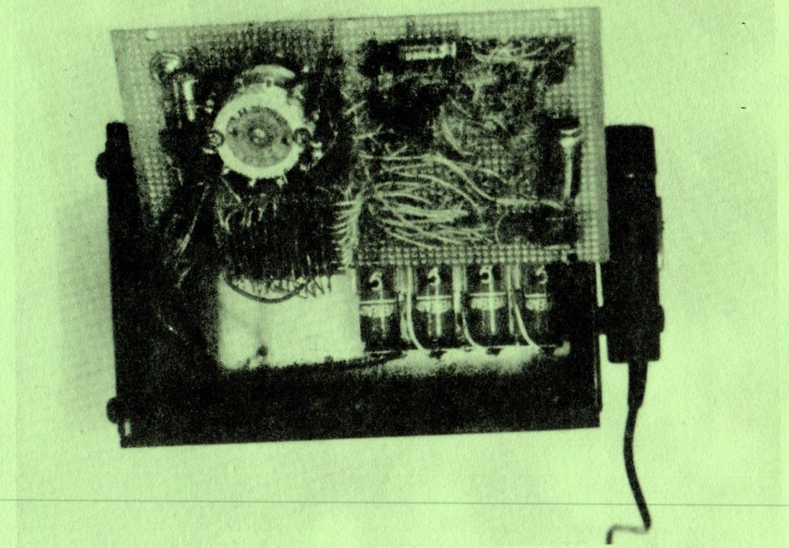
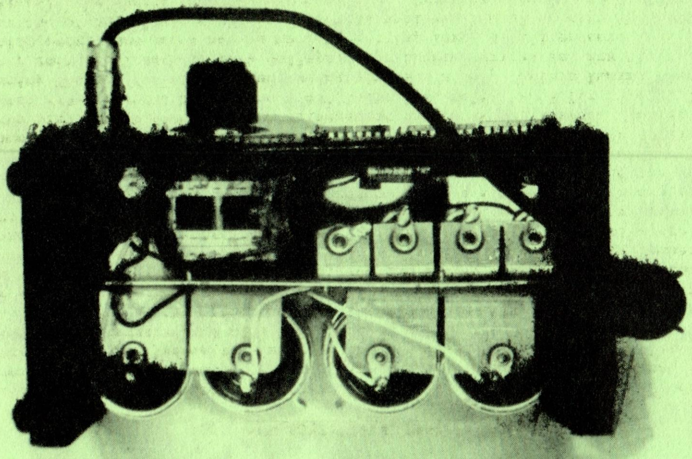
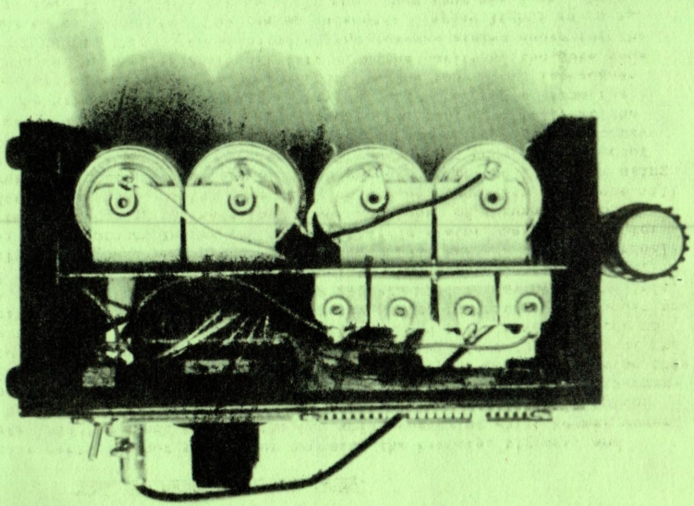
You should open up a piano now and familarize yourself with the insides. Notice the tuning pins along the top. Also, notice the two basic large groups of strings referred to as the treble group and bass group. The bass group is found at the left while the treble group is found at the top right. Now, notice that the treble strings all are arranged at the extreme right end in groups of three strings each while the bass group near the left middle has two strings to a group while on the far left only one large, long string is found in independent arrangement. Each of these smaller groups of 3, 2, & 1 strings produce one of the notes on the piano. Most pianos have 88 keys that produce 88 notes from these 88 sets of strings.

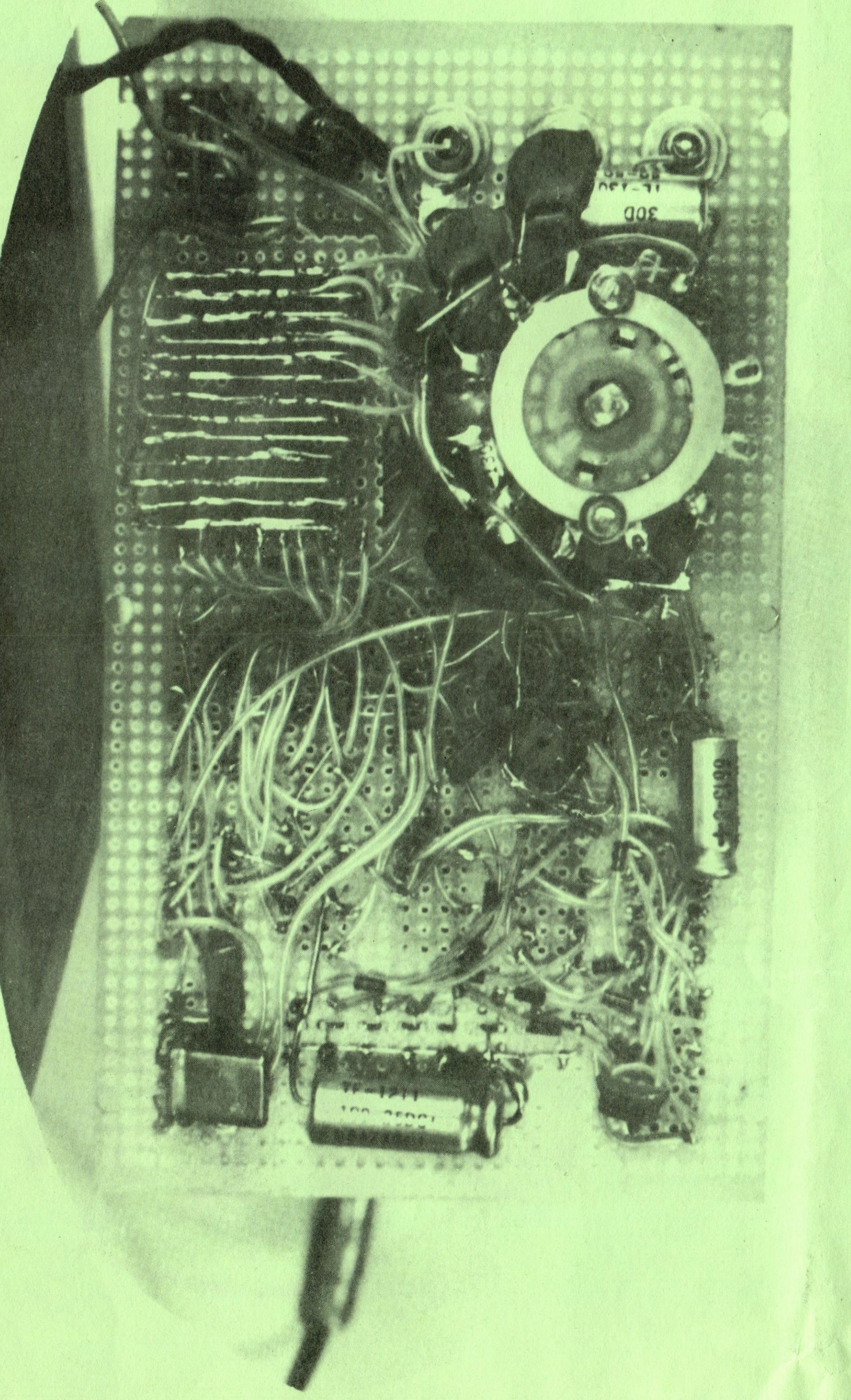
Select a key in the middle of the keyboard and while pushing it down, a hammer will move against a small group of strings. Some hammers strike three strings at a time (most treble group) while others strike only 2 strings or 1 string (bass group). Each of the three strings struck by a treble hammer are tuned to the same note, if you want your piano to have "hard scale tuning" quality. However, you may experiment with tuning one of the three strings slightly higher or lower in pitch to obtain a bar room piano effect. This effect is also enhanced even more by putting thumb tacks in the hammers where they strike the strings, however, be warned THAT THUMBTACKS MAY CAUSE THE STRINGS TO EVENTUALLY BREAK DUE TO FATIGUE. When all 3 strings of a note are tuned to exactly the same note then the strings are said to produce the note in "unison". If one string is tuned slightly out of tune with the other two, you will hear a tremolo effect. This quiver in pitch sound is referred to as a "beat note". This quivering sound of pitch will increase in speed as the out of tune string is made more out of tune. In classical concert pianos this is an undiserable effect. All three strings should be tuned in unison or near perfect pitch with each other thereby producing the same note in unison. The above applies also to the pairs of strings found in the bass group as well.

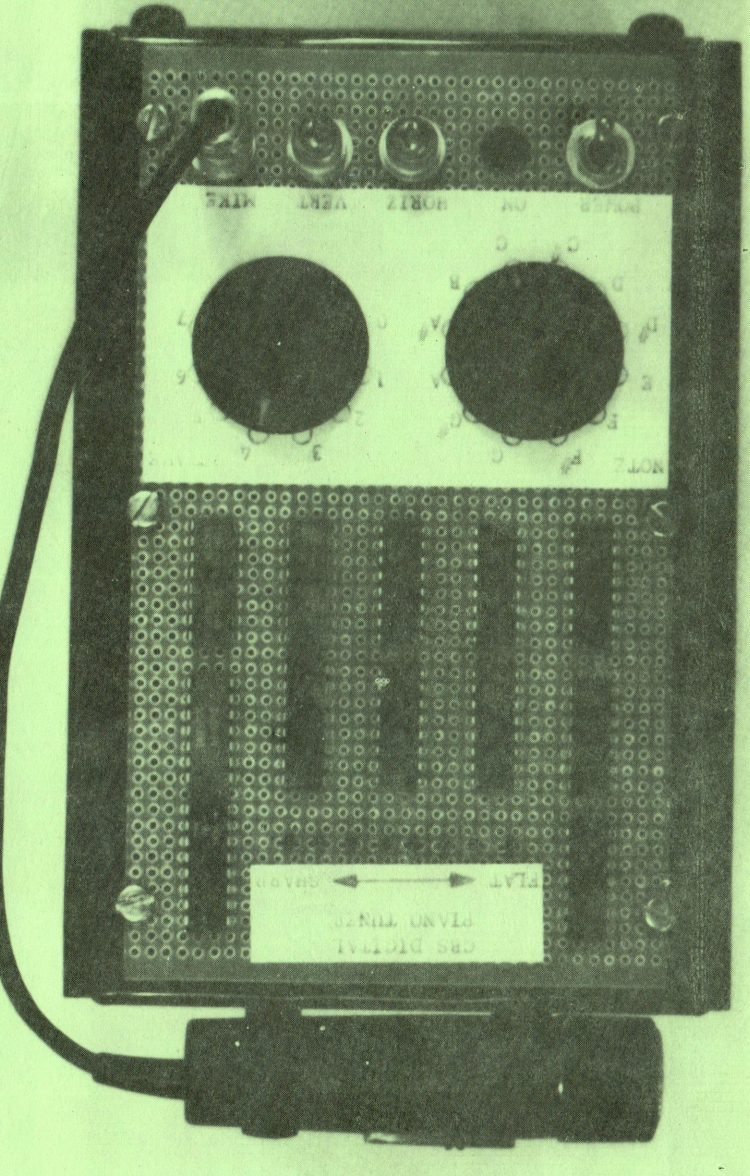
Now, you are probably familar with the name of the notes of a musical scale where only 12 different names are used after which they repeat an "octave" higher or lower in pitch. An octave means that one note is exactly double (higher) or half (lower) the frequency of another note. For example, looking now at the "construction hints" drawing part of a keyboard is shown with the name of some of the notes presented. Notice on your piano that "middle C" (C_3) is found under the label. This is a good place to start tuning any piano. Start with "middle C" (octave #3) and work up the keyboard from "middle C" and then down. The notes at the extreme ends of the piano are more difficult to tune due to the quick decay in volume of the note at the high end and at the low end due to the fact that a very slow beat note is produced by out of tune strings. This is difficult for piano tuners using their ears to accomplish this.

NOW, HOW ABOUT TUNING A PIANO!

Remove the upper case parts of your piano thus exposing the hammers, strings, and tuning pins. Next, locate "middle C" and operate the key while observing which hammer moves. Find the strings played by the moving hammer. Wedge the appropriate mutes into all but one string of the sounding note so that only one string is allowed to sound when the key is operated. Identify the tuning pin corresponding to this note and place your tuning hammer on this pin, being careful not to turn it yet. Place your GBS PIANO TUNER within a foot or so of the string on an appropriate surface. Turn the note selector to "C" and the octave selector to "3". Turn it on and strike the middle C key. Looking at the tuning indicator, you should see a pattern indicating the tuning quality. Most likely the pattern will be moving to the left, because most pianos will be flat in pitch awhile after tuning. Try tightening the string, raising the pitch slightly, while observing the display. You should see the pattern gradually slow down and stop. This is the proper tuning indication: that is a stationary pattern for correct tuning. Do not turn the tuning pin more than about an eighth of a turn to avoid getting the string too far out of tune. After some practice and patience this technique will become very easy. Now mute the other strings for middle C one at a time and tune them using the corresponding tuning pins. Next go to C# (a black key). Note that your note selector has just crossed the dark line between C & C#. This is to remind you to change your octave selector up or down, in this case up to octave #4. In actual practice, especially at the higher and lower ends of the keyboard, you may want to try an octave up or down from the actual one you are tuning for possible improvement in tuning indication. This is because some strings produce harmonics in the note that interfere with the purity of the note thus making it more difficult to tune. This is complicated by the reasons stated above for the notes produced at the ends of the keyboard. The tuning indicator display lights up in a normal pattern that may be four of the LED's lit up while the other four are dark. This pattern then moves either left or right depending on whether the note is flat or sharp. If on the other hand your string has extra harmonics other than the fundamental and in addition these harmonics are much stronger than the fundamental, then the display will probably show some other pattern depending on the strength of these other harmonics. The important thing is that there is a distinct pattern that moves slowly to the left or right and if the note is correctly tuned, then this pattern will be almost stationary. It is not necessary to tune the note until the pattern is completely stationary since the display is very sensitive as you will see, and hence you will find that it is exceedingly difficult to completely stop the pattern since most pianos are not designed to be tuned to the great accuracy that the GBS Digital PIANO TUNER is capable of indicating!




MIKE VERT HORIZ ON POWER
NOTE
FLAT SHARP
CBS DIGITAL
PIANO TUNER