pacitor increases low-frequency stability. One of my earlier versions of an ST-70 modification used a cascode gain stage, direct-coupled to a split load phase inverter (the same phase splitting technique of the original Dynaco driver stage). This configuration was very stable, but suffered from an output swing limited to one-third the supply voltage.

What we needed (if possible) was large swing potential (with dynamic balance) and direct coupling. In *Radio-Electronics* (September 1955) article and again in *Wireless World* (June 1956), L. B. Hedge described the "long-tailed cascode pair" configuration, in which a differential amplifier was configured using a pair of cascode "sides." This elegant circuit offers the most direct solution to the demands of the output stage. The degree to which it can function as a true differential amplifier (and therefore an effective phase splitter), depends on the signal coupling from cathode to cathode. This, in turn, depends on the biasing impedance being as high as possible at this point. To approximate a current source, Hedge specified a large value resistor (47kΩ) returning to a negative voltage supply.

The additional power supply (a major drawback of his approach) has even greater economic consequences today, given our insistence on highly regulated supplies. Through the use of a transistor current source, we can realize a high source resistance without the negative voltage requirement. This current source contributes significantly to this circuit's effectiveness as a phase splitter.

Transistor Q101, with its associated base and emitter components, serves as the current source; biased into the proper quiescent operating mode from the voltage present at the output of the driver stage. A large AC component at these points is out of phase and therefore cancels to zero (effectively). The remainder of the driver circuitry is a very conventional self-bias cascode circuit on each "side."

Output

The output stage is reconfigured from the original "ultralinear" circuit (in which the screen grids were fed from the output transformer primary winding) to the fixed screen circuit (fixed supply voltage). The voltage supplying the screens is tightly regulated, playing a major role in the sonic formula.

The output tube bias voltage is derived from a fixed-zener regulated sup-

ST-70 PARTS LIST — ***optional bias balance circuit**

Item	Description	P/N	Source	Quantity
Capacitors				
C1 a-d	30, 3x20μF Quad	298906	ST-70	1
C2, 3	100μF, 16V electrolytic	20NH100	Mouser	2
C4	0.1μF, 600V Mylar (Sprague 6PSP10)	926-2168	Allied	1
C5	47μF, 100V electrolytic	19AX047	Mouser	1
C6	47μF, 50V electrolytic	20NR047	Mouser	1
C7 a, b	.02μF ceramic	224403	Dynaco	1
C8	10μF, 450V electrolytic	19FF010	Mouser	1
Cx01, 02	0.1μF, 250V polypropylene	23PQ410	Mouser	4
Cx03, 04	0.47μF, 400V polypropylene		ST-70	4
D1-15	1000PIV	333-1N4007	Mouser	15
F1	3A slow blow fuse	504-MDL-3	Mouser	1
IC1	dual bi-FET op amp	551-UPC812C	Mouser	1
IC2	adjustable + V-reg	551-UPC317H	Mouser	1
L1	Choke	423354	ST-70	1
Q1,3,x01	NPN SS transistor	333-KN4400	Mouser	4
Q2	HV/Hi-power transistor	D1341	MCM	1
Q4, 5	HV/Med power transistor	511-TIP50	Mouser	2
Resistors				
R1	not used			
R2	75Ω, 6W	ME285KNA620-75	Mouser	1
R3	1kΩ, 6W	ME285KNA620-1K	Mouser	1
R4, x08,x09	3.3MΩ, ½W	29SJ500	Mouser	3
R5, 7	10kΩ, ¼W	29SJ250	Mouser	2
R6, 8	470Ω, ¼W	29SJ250	Mouser	2
R9	39Ω, ½W	29SJ500	Mouser	1
R10, 11, 26 R12-15	4.7Ω, ½W	29SJ500	Mouser	2
x18, x19	470kΩ, ½W	29SJ500	Mouser	8
R16	1kΩ, ½W	29SJ500	Mouser	1
*R17, *18, 21	22kΩ, ½W	29SJ500	Mouser	3
R19, 20	25kΩ, ADJ Bias (Bourns 3352H-1)	754-8210	Allied	2
R22, 116 x06, x07	100Ω, ½W	29SJ500	Mouser	6
R23	47Ω, ½W	29SJ500	Mouser	1
R24	100kΩ, 3W	P100KW3	Digi-Key	1
R25	332Ω, 1%, ½W	29MF500	Mouser	1
Rx01, x04 x05, x12	1MΩ, ½W	29SJ500	Mouser	8
Rx02, x03	47kΩ, 3W	P47KW3	Mouser	4
Rx10, 11	33Ω, ½W	29SJ500	Mouser	4
Rx13	1kΩ, 1%, ½W	29MF500	Mouser	2
Rx14	352kΩ, 1%, ½W	29MF500	Mouser	2
Rx15	4.75kΩ, 1%, ½W	29MF500	Mouser	2
Rx17	47.5kΩ, 1%, ½W	29MF500	Mouser	2
*Rx20, *x21	39kΩ, ½W	29SJ500	Mouser	4
*Rx22	20kΩ, adjustable (Bourns 3386F)	754-3211	Allied	2
Rx23, x24	1.8Ω, ½W	29SJ500	Mouser	4
Rx25	15.6Ω, 5W	120150	ST-70	2
Miscellaneous				
(1) SW1 DPDT slide switch, 576S5022CD03-0			Mouser	
(1) T1 PA-060, 464006 (ST-70)				
(2) T2, 3 A-470, 454326 (ST-70)				
(4) V1, 2, 7, 8, EL34/6CA7			Triode	
(4) V3-6, 6DJ8/6922 (Siemens)			Triode	
(2) X1, 3 TO-220 heatsink, 33HS222			Mouser	
(1) X2 TO-3 heatsink, HS103-1.25			Allied	
(25) X4 PWB terminals			Concord	
(8) X5 spacer 4-40x1 inch, 839-2337			Allied	
ZD1-4 not used (91V, 5W zener diode)				
(1) ZD5, 15V, .5W zener diode, 570-1N4744A			Mouser	
(1) ZD6 30V, .5W zener diode, 570-1N4751A			Mouser	
(1) ZD7, 6.2V, .5W zener diode, 570-1N4735A			Mouser	