Nicolas Collins
'Pea Soup' – A History
September, 2011

Background

Microphone + speaker = feedback. I can't believe there are more than a handful of people on our planet who haven't heard this primal electronic squeal. But then I am of the feedback generation: from John Lennon's disruptive skid into "I Feel Fine" in 1964 to Jimi Hendrix's performances in the films of the Monterey Pop Festival and Woodstock, feedback was as essential a voice in the music of my youth as guitars and drums. When I arrived as a freshman at Wesleyan University in 1972 and fell under the twin influences of John Cage and Alvin Lucier, feedback re-asserted itself as a fortuitous gift.

Cage's admonition that "any sound can be a musical sound" induced a kind of sonic paralysis in me. I spent hours in front of the studio's synthesizer only to realize, at the end of the night, that I had no preference for one configuration of patchcords over another. But plug in a microphone, turn up the speaker, and feedback's Zen-like infinite amplification of silence produced sounds with minimal interference on my part. Feedback served as a sort of electronic *I Ching*: I moved the mike instead of tossing yarrow sticks, notes emerged, but I never knew which pitch would pop out next. The results were more a question of acoustics, however, than of pure chance -- the overtone series became my hexagrams -- and here's where my second role model, Lucier, exerted his influence.

I grew up in a rather unmusical family, with architectural historians for parents. At age 18 my interests were all over the place: pop music, electronic music, Indian music, zoology, geology, art, architecture, Latin American literature…. Without a "serious" musical background to draw on, I found Lucier's embrace of axiomatic acoustics in compositions such as *Chambers*, *Vespers* and *I am sitting in a room* deeply reassuring. Physical acoustics – and the notion that a room or a teapot could be a musical instrument and an echolocating bat a player -- became the conceptual glue with which I sought to unify my disparate interests into a meaningful, personal musical style.

The Wesleyan studio had a Sony 152SD portable stereo cassette recorder, about the size of an attaché case. I could trick it into serving as a microphone preamplifier by poking the end of my pinkie against a tab in the cassette well while pressing down the "Record" button. The line outputs could be patched into any amp and speakers, but the Sony also had a robust internal speaker that transformed the recorder into a self-contained, portable feedback instrument. Moreover, its built-in limiter did a wonderful job of taming feedback's shriek, reducing it to a mellow sine wave (a fine example of corrective "negative feedback" being harnessed to keep runaway "positive feedback" under control)[1].

Figure 1: Sony TC152 cassette recorder (1974)

For the next three years I ran feedback through as many variations as I could. I carried the Sony out and about and used feedback to "play" culverts under roadways as if they were huge trombones. Lucier owned a set of Shure industrial contact microphones (intended for analyzing noises in machinery) with which I could similarly play solid objects such as tables, walls, floors and tree trunks[2]. I resonated wind and brass instruments by embedding a tiny lavaliere microphone in a mouthpiece and feeding it back with a speaker; performers used fingering or slide position, as well as movement of the instrument in space, to induce the feedback to break to different overtones[3]. Later I substituted small speakers for some of the mouthpiece microphones, transforming trombones and tubas into "speaker-instruments", and I manipulated feedback between pairs of instruments without the need for an external PA[4].

The Countryman Phase Shifter

When the Electronic Music Studios opened in the new Wesleyan Arts Center in 1973, Lucier disconnected the keyboards from the two Arp 2600 synthesizers and locked them in a closet. This was done to pre-empt Switched-on Rock riffs, but the students' placid acceptance of this musical snobbery was indicative of the "proto-digital" direction that synthesis was taking. Rather than playing the Arp directly in the manner of an elaborate electric organ, we interconnected the various voltage-controlled modules (oscillators, filters, amplifiers, etc.) to create self-governing networks that, left to their own devices, created complex, cyclical patterns. By the end of the decade we were programming similar work on primitive, pre-Apple microcomputers like the Kim-1, but during my undergraduate days plugging patchcords and twiddling knobs was as close as I got to writing lines of code[5].

It was in this spirit that I began building synthesizer patches to control feedback. My goal was to emulate electronically the movement of the microphone in space and thus create some kind of automatic feedback variation machine. I cobbled together numerous arrangements of filters and panners, modulated by low frequency oscillators, before stumbling upon the Countryman 968 Phase Shifter[6].

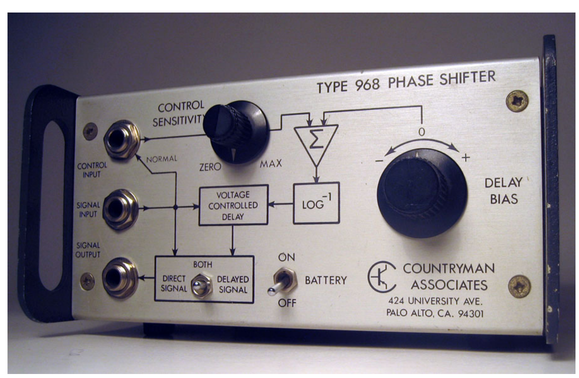

Figure 2: Countryman 968 Phase Shifter (1974)

Phase Shifters are generally known for the characteristic shwooshing sound that defined the disco era, but in the time before digital delays these devices were the only practical way to produce variable short time delays on audio signals[7]. Lucier had made some field recordings of the electromagnetic signals produced by meteorites, lightning, the dawn chorus and other atmospheric disturbances; he was interested in moving these sounds around a concert space and had read about "Haas Effect Panning" – a technique that produces very convincing spatial movement of sound using small time delays (instead of the more typical method of adjusting the balance of loudness amongst the various speakers). The Countrymen were bought for these panning experiments. In the spring of my sophomore year Lucier delegated me to figure out how to get the Phase Shifters to pan his tapes around the Merce Cunningham Dance Studio, where he had been asked to provide music for a Cunningham Event. Two Arp 2600s and three Countrymen later I had an absurdly complicated patch that convincingly swept his "Sferics" around the room in response to their own loudness envelopes[8].

Back in Middletown, I adapted my patch to the task of using a similar loudness envelope "move" a live microphone, instead of panning Lucier's pre-recorded sounds. Over a period of months I whittled away modules until I was left with the simplest of all possible configurations:

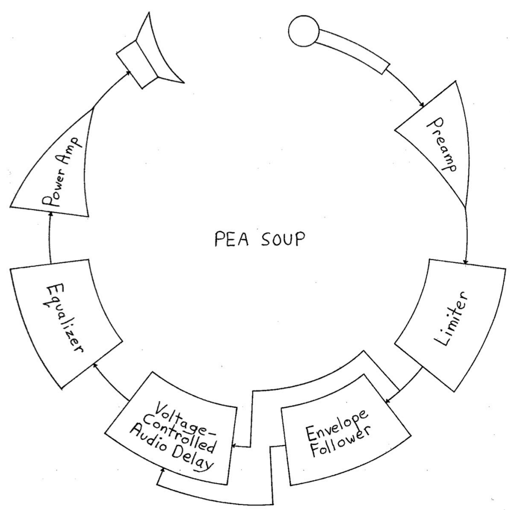

Figure 3: ***Pea Soup*** **patch diagram (1976)**

I discovered that when I connected a microphone to a speaker through a Phase Shifter, varying the delay emulated moving the microphone towards and away from the speaker, in turn causing the feedback to change frequency. Controlling this virtual movement with the loudness of the signal (via an "envelope follower" circuit conveniently built into the Countryman) mimicked a nervous sound engineer jerking back the microphone as soon as it starts to feed back.

I threw in my trusty Sony limiters to keep the signal smooth. Whatever equalization was available in the sound system (usually nothing more elaborate than the bass and treble tone controls on the studio's Dynaco amplifiers) could be tweaked to adjust the frequency range of the feedback. By experimenting with the different microphones available in the studio I discovered that *omnidirectional* mikes produced a much wider, less shrieky range of pitches than the more common unidirectional cardioid microphones (even the best cardioid mikes have rather irregular off-axis frequency response, which I suspect affects their feedback characteristics.)[9]

A single chain of mike>>phase-shifter>>speaker tended to seesaw back and forth between two pitches of feedback. But when two more independent channels were added, the various channels interacted acoustically to produce more varied and extended melodic patterns[10]. Moreover, these patterns were hypersensitive to the smallest change in acoustic conditions: walking a few steps across the room, making a sound, even opening a door or window could cause a note to be dropped from the melodic phrases or a new one to be added.

Figure 4: Electro-Voice 635a omnidirectional microphone – the perfect feedback mike

I had stumbled upon a remarkably simple electronic network that created a site-specific "architectural raga" out of a room's resonant frequencies. The phrasing was a function of the reverberation time – bigger halls yielded slower patterns. Perhaps the most elegant aspect was the responsiveness of the sound itself: one "played" this system not by twiddling knobs or pushing buttons, but by moving or making sounds within field of the feedback[11].

The 1970s saw the emergence and maturation of the notion of the "circuit as score" – the assumption that a configuration of electronic components was as legitimate an expression of compositional intent as staves on manuscript paper. I had no desire to dictate specific instrumental actions or body movements, but I was nonetheless quite content to claim this array of modules as my "composition." I dubbed it *Pea Soup*: a reference to the first letters of the core technology (Phase Shifter) and to the expression "as thick as pea soup", which I thought conveyed well the experience of standing within the sea of feedback. The first performance took place in a lunchtime concert in the Wesleyan Electronic Music Studios on October 24, 1974[12].

Over the remainder of my undergraduate career at Wesleyan I produced several performances and gallery installations of *Pea Soup* on and off campus. With Lucier's encouragement and connections, his small but assertive posse of students pursued concert exchanges with other colleges around New England. I drafted players on site or from amongst my fellow students – most frequently a singer named Geordie Arnold, who for some time was a member of Steve Reich's ensemble. I supplemented the electronics with verbal instructions, consisting mostly of admonitions to "do less." The site-specificity of *Pea Soup*'s character made it a satisfyingly portable work, familiar yet surprising wherever it was played. I compiled an overwrought prose score for inclusion in my undergraduate Honor's Thesis[13], but left the Countrymen and *Pea Soup* behind when I graduated in 1976.

Reconstruction

Feedback returned to my music with the regularity of a comet over the next few decades, even as my technological palette shifted from homemade circuits to microcomputers to human improvisers to chamber ensembles and back to handmade circuits[14]. In 1997, while living in Berlin as a guest of the DAAD Künstlerprogramm, I was asked to revive *Pea Soup* (after a hiatus of more than 20 years) by Kammerensemble Neue Musik Berlin, who were interested in taking on some interactive works for electronics and players. I reconstructed the original phase shifter circuit with the aid of a schematic generously provided by Carl Countryman himself (who had ceased manufacturing the device sometime in the mid-1970s)[15]. Sadly, the Countryman contained one custom-made sub-module that was very difficult to replicate, and try as I might I was never able to approximate certain characteristics of the original design. In 2000 I bought a Moogerfooger M103 Phaser which (thanks this time to documentation directly from the hand of Robert Moog) I modified to mimic the behavior of the original Countryman as best I could; a beautiful circuit indeed, but still not exactly what I needed for this piece. I shelved my boxes after a few more performances and moved on to other projects[16].

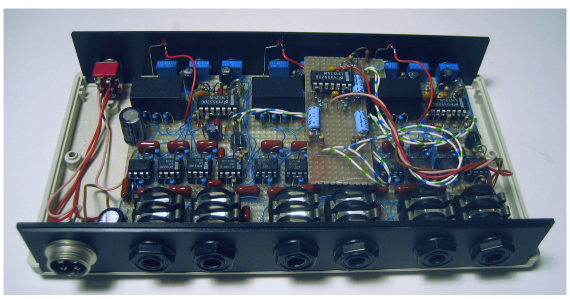

Figure 5: 3-channel Countryman copy, Nicolas Collins (1999)

Figure 6: Modified Moogerfooger M103 Phase Shifter (box on right contains envelope followers), Nicolas Collins (2001)

But the Berlin revival of *Pea Soup* was indicative of a wide-spread nostalgia, at the cusp of the millennium, for earlier electronic music: John Cage's *Cartridge Music* (1960), Takehisa Kosugi's *Micro 1* (1964), Steve Reich's *Pendulum Music* (1968) and David Tudor's *Rainforest IV* (1973) all returned to the concert stage after decades of retirement. This interest in historic works, many of them dependent on obsolete or composer-built technology, coincided with the spread of music programming languages that ran on affordable computers powerful enough for real-time audio signal processing. The net result was a wave of "porting" of older, hardware-based electronic repertoire into software formats. Sometimes the programming was done by the original composer (David Behrman comes to mind); other times enthusiastic young fans took on the task, adapting older solo works for the emerging format of the "laptop ensemble". The quirky look of a table of homemade circuits and cheap effect pedals was lost on the computer screen, and there often was some subtle change in sound quality. But for performance convenience and ease of distribution this method of reconstruction could not be faulted.

Shortly after moving back to America in 1999 I was asked to resurrect another circuit-based composition from the mid-1980s, *Devil's Music*. Unable to locate or rebuild the proper hardware, I programmed a workable facsimile in Max/MSP[17]. Around the same time I undertook a similar software adaptation of *Pea Soup*.

The impetus for the revival of *Devil's Music* was external: a request for a version that could be played by multiple performers in a club context. Limitless duplication and open distribution made software seem the most appropriate strategy. The work on *Pea Soup* was more selfish: my fascination with essential elements of the composition had been re-kindled by recent circuit-based performances, and I wanted to bring the piece back into my touring repertoire. The final trigger was the discovery of a third party Max "object" (set of software instructions) that emulated the core mathematical function of a phase shift network, and allowed me to delay the audio by degrees of phase – as in the original analog circuits – rather than the absolute time, as is more common in the digital domain[18]. I successfully programmed my own replica of a Countryman Phase Shifter using this function. I added a basic limiter and some simple equalization, I copied and pasted the whole chain to make three discrete channels, and by the summer of 2001 had created a reasonable (and compact) approximation of my 1974-era technology.

In the subsequent decade I have presented over 50 performances and installations of the new *Pea Soup*. The somewhat severe, strictly minimalist, task-oriented composition of the 1970s has been replaced by something more akin to "improvising with architecture" – with the right players I need say little to facilitate a good performance. In the hands of a sensitive musician with a good ear and a modest ego the piece is virtually foolproof. The behavior of the technology hasn't changed significantly (despite its shift from hardware to software), feedback is still feedback, and architectural acoustics certainly are the same now as they were in 1974; but over the past three decades musicians in general have become more skilled at performing open-form compositions that require an instinct for improvisation.

***Pea Soup II* – the Software**

It's tempting to "improve" a circuit when one programs an equivalent in software: physical sliders and knobs have limits past which they will not move, but numbers in a program can always be made larger or smaller. Sometimes it's important to retain what are, in software, "artificial" limitations in order to remain faithful to the essential character of the original work. At the same time, some traits in hardware are the result of economic or technological factors that, if eliminated, could actually benefit the work.

Every year or so I return to the program to tweak its behavior or add features, and my challenge has been to preserve the simple, elegant core of the old analog

Pea Soup while adding appropriate innovations that are only possible today thanks to the power of software. ("Authenticity", in this particular case, is somewhat irrelevant: it's my piece, I'll change it as I want.)

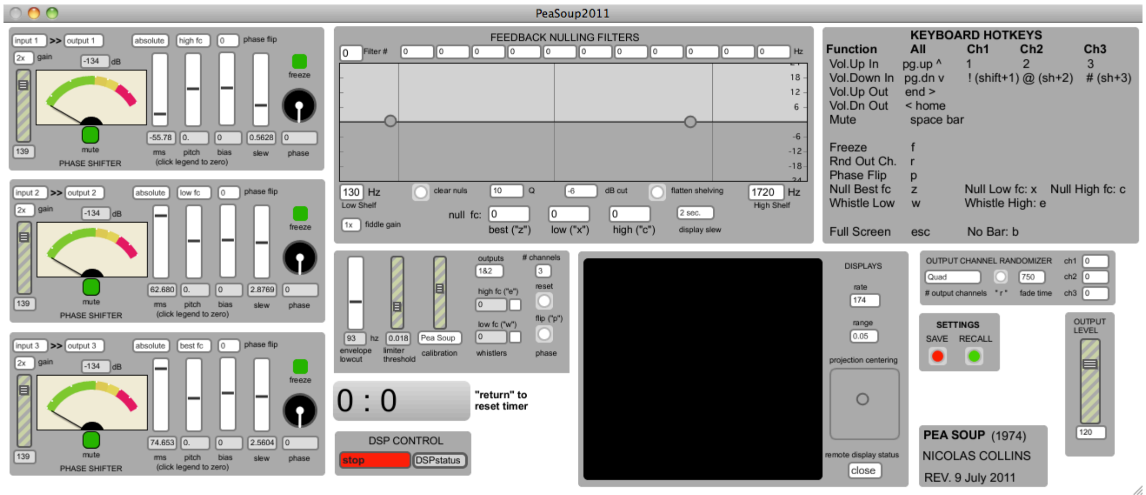

Figure 7: Max/MSP application for software realization of *Pea Soup*

Here is an overview of the features implemented in the 2011 version of the software[19]:

- **Countryman Phase Shifter**: three channels of a reasonable facsimile of the Model 968, each with a built-in Envelope Follower to change phase delay in response to loudness. I've added a Pitch Follower circuit so that changes in the pitch of the feedback (as well as loudness) can shift the phase, and I extended the maximum number of degrees of phase shift; otherwise it's "stock."
- **Limiter**: a simple limiter on each channel to prevent distortion, with adjustable threshold (loudness at which limiting sets in).
- **Equalization**: low frequency and high frequency shelving filters with boost and cut controls, as well as adjustable corner frequencies. One can use this EQ to roll off shrieking high frequency feedback, boost the bass response, etc.

These three modules are essentially software equivalents of the analog circuits in the original *Pea Soup* patch. To these I have added a few routines that extend the capabilities of the system in ways that would have been very difficult before the advent of digital technology:

- **Feedback Nulling Filters**: with a tap of the "x" key on the Macintosh keyboard a filter locks onto the currently sounding pitch of feedback and attenuates that frequency just enough to eliminate it. This mimics an attentive sound engineer tuning the equalization on the mixer to minimize feedback from mikes on the stage. My module has 11 such notch filters: whenever a particular frequency of feedback gets too persistent, an "x" will knock it out and allow other pitches to replace it. Given the nature of the harmonic series that determines room resonance, with each strong frequency thus eliminated the remaining overtone set becomes more dissonant – judicious use of the Nulling Filters can steer *Pea Soup* through "key changes" as the piece unfolds.

- **Channel Swapper**: using a multi-channel audio interface one can connect each of the three Phase Shifter channels to any of four outputs (assuming a typical four-channel PA system.) Since the distance between a mike and a speaker affects the set of feedback pitches, re-routing the three mikes amongst the various speakers changes the pitch "vocabulary" of *Pea Soup*. A tap of a hot-key will randomly re-assign the channel allocations. Another nice way to introduce changes to the performance.
- **Whistler**: playing or singing at the same frequency as the feedback, then de-tuning slightly, produces a beating effect that – if sustained – often causes the feedback to break to a new pitch. Via a trackpad or mouse, the Whistler lets the user mix a pair of sine waves into the output, and de-tune them symmetrically above and below the sounding feedback pitch, to induce beating and pitch breaks.

The best performances of *Pea Soup* result from playing *acoustically* and moving within the spatial field of the feedback. Manipulations of the electronic circuits or software are best done as part of the "tuning" process, and I encourage performers to interfere with the patch as little as possible once the performance is underway. The Nulling Filters are useful for eliminating strong resonances from the system in the course of the sound check; the Channel Swapper can be used to find the best mapping of mikes to speakers. But, used judiciously, the Nulling Filters and Channel Swapper can subtly modulated the "key" of the feedback over the course of the performance, and the Whistler serves as an acceptable substitute for a live musicians.

Since late 2002 I've been emailing the software to musicians interested in staging performances. The MEA group in Amsterdam has *Pea Soup* in their repertoire, and Swiss pianist Petra Ronner has begun performing the work. In the fall of 2011 I uploaded the latest revision to my web site for open distribution[20].

Pea Soup To Go

Belying its 1970s roots, *Pea Soup* is a classic open-form composition: the score and technology are static, the feedback always sounds more or less the same, yet the actual pitch material is entirely site specific, and varies significantly from performance to performance. Every room has its own tuning. Both during its analog days, and after I had shifted over to software, I often performed *Pea Soup* as the opening piece on a concert program -- it serves as the *alap* section of my architectural raga, slowly revealing the essential musical characteristics of the concert space (characteristics that influence every subsequent piece played in the room, whether one is conscious of this acoustic underpinning or not.) I recorded many of these performances, and after I had accumulated a few dozen sound files I toyed with the idea of editing them into a long tape composition. I imagined that, properly sequenced, each "room chord" would modulate to the next like a glacially slowed down Progressive Rock composition from the 1970s.

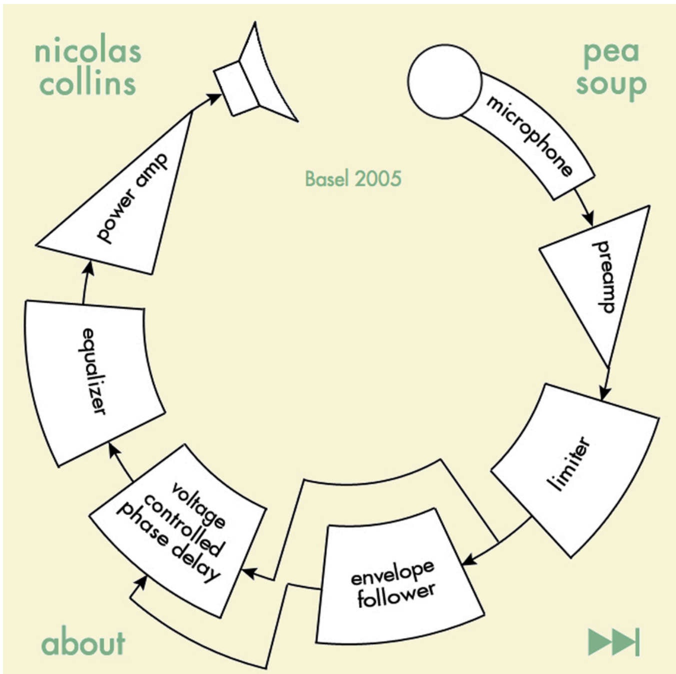

Figure 8: ***Pea Soup To Go*** **(2011), software for shuffling concert recordings of** ***Pea Soup***

But, alas, the same Cagean stasis that drove me to feedback in 1972 rendered me incapable of choosing one pretentious chord change over another. So I took refuge in that most ubiquitous mass-market adaptation of Cage's philosophy: "Shuffle Play." I worked with a graduate student, Wesley Wilson, to craft a web application that plays back my library of *Pea Soup* recordings in pseudo-random order. The start and end points are randomized as well, so that each file doesn't always start and finish at the same time. Long cross-fades (15 seconds) make for a seamless mix. The end result, *Pea Soup To Go* (2011) is an encyclopedia of room tones in the form of an "audio screen saver" [21].

Afterword

I am quite aware that there is something slightly pathetic about a composer in his fifties revisiting a "student work", but taking *Pea Soup* back out on the road re-awakened my primal interest in the musical implications architectural acoustics. As I mentioned earlier, the Nulling Filter routine in the software version of *Pea Soup*, when pushed to the extreme, reveals that the more remote overtones of room's resonant frequencies tend towards greater dissonance than the pitches that dominate feedback in an un-equalized sound system. I found this intriguing from the standpoint of harmonic theory, and have recently begun work on a computer program that uses an extension of the Nulling Filter to analyze the overtones of a room and display the first 24, in order of strength, as conventional staff notation. The staves are projected for the musicians (and audience) to see. The players take these pitches as tonal material for simple variations, as they slowly make their way into the more obscure regions of the overtone set. The audience hears an odd hybrid of Serial and Minimalist music. At the end of the night the notation is printed out and remains as a musical portrait of the concert space.

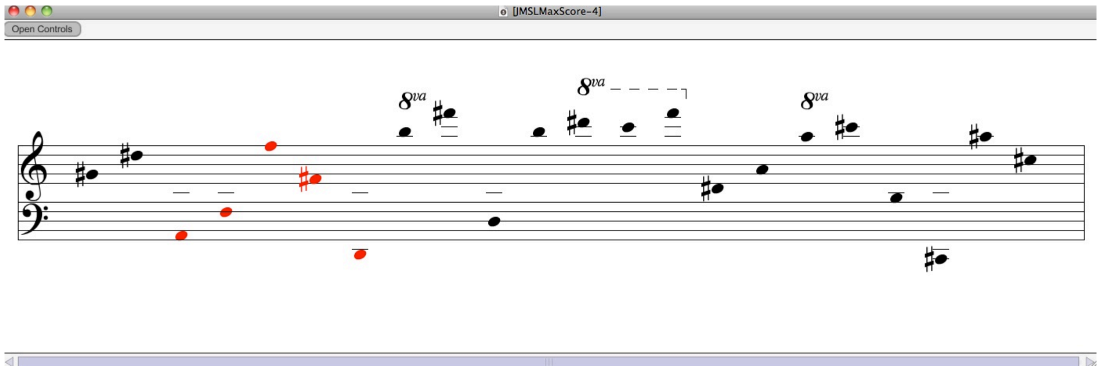

Figure 9: *Roomtone* (2011), score from real-time analysis of room acoustics

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[1] See Attachment 1.
[2] *Nodalings* (1973). See http://www.nicolascollins.com/texts/nodalingsscore.pdf.
[3] *Feetback* (1975). See http://www.nicolascollins.com/texts/feetbackscore.pdf.
[4] *Q* (1975). See http://www.nicolascollins.com/texts/qscore.pdf. For a general overview of my work with feedback see: Nicolas Collins. "All This And Brains Too". Resonance Magazine, Vol. 9 #2 (2002). Available here: http://www.nicolascollins.com/texts/allthisandbrains.pdf
[5] For a good description of pre-computer algorithmic music systems see: Joel Chadabe. *Electric Sound – The Past and Promise of Electronic Music*. Prentice Hall, NJ. 1997. Pp. 286-291.
[6] See Attachment 3.
[7] A technical detail: whereas a digital delay delays all frequencies of an audio signal by the same amount of time, a phase shifter delays the signal by a certain number of *degrees of phase* (typically from 0 to 1080 degrees or so). The absolute delay time varies according to the frequency of the signal: 360° of phase shift on 440hz = 2.2ms, while the same phase shift delays a 1kHz signal by only 1ms. In this way a phase shifter smears the frequency spectrum in time in a very counterintuitive fashion. Not only is the resulting delay very, very short (typically less than 10ms), but this smear changes the sound in ways that cannot be effectively emulated with later digital delays.
[8] A CD of his ionosphereric recordings, minus my panning system, was later released by Lovely Music: Alvin Lucier. *Sferics*. Lovely Music LP 1988.
[9] My favorite feedback microphone is still the Electro-Voice 635a dynamic omnidirectional mike, of which we had several in the Wesleyan studio. A popular reporter's interviewing microphone that is still in production today, more than 50 years after it was introduced. See Attachment 2.

[10] Three channels turned out to be the magic number: with just two channels (stereo) the patterns never got rich enough, but adding a fourth didn't make noticeable improvement. Luckily the studio had three Countrymen, but one developed odd intermittent noise after a year or so. At the suggestion of some sage we discovered that placing the Phase Shifter in a freezer overnight warded off the noise for 30 minutes or so, but three-channel performances continued to be risky endeavors.
[11] In later years, especially when I was working at STEIM in Amsterdam in the 1990s, I encountered many instruments and installations that used ultrasound or infrared motion detectors to track and respond to movement, but I've never heard another music system in which the sounds themselves were their own controlling element.
[12] I was assisted in this concert by Robert Poss, who was at the time a promising student in a class I was teaching (although I was a mere undergraduate) because Lucier was on sabbatical that semester. I continued to work with Robert after we both left Wesleyan: I produced a few records by his rock bands, we ran an indie label together, he masters my recordings these days, I build him effect boxes, and we continue to play together upon occasion.
[13] See http://www.nicolascollins.com/texts/peasoupscore76.pdf.
[14] See Collins. "All This And Brains Too".
[15] See Attachment 4.
[16] One performance, from the Limbo Festival in Plasy monastery, was released on a label started by an ex-student of mine shortly after he graduated from SAIC: Nicolas Collins. *Pea Soup*. Apestraartje CD (2004).
[17] See: Nicolas Collins. "Some Notes On The History Of *Devil's Music*". Notes to *Devil's Music*. EM Records CD and LP, 2009. Also available at http://www.nicolascollins.com/texts/devilsmusichistory.pdf
[18] A Hilbert Transform, to be specific. I am a lousy mathematician and a sloppy programmer, but in the early days of the analog *Pea Soup*, when I was collecting circuit diagrams in pursuit of building my own phase shifters, I had stumbled upon a short article in an electronic engineering magazine that showed a rather unusual implementation of a phase shifter using an analog realization of something called "a Hilbert Transform", a function normally associated with analog frequency shifter such as that made by Harold Bode (see Attachment 5.) Some 25 years later the name "Hilbert" caught my eye in a list of Max objects available from IRCAM, the venerable French computer music research center. Once downloaded, that chunk of code became the core of the digital realization of *Pea Soup*.
[19] A more detailed description of the software can be found in the current performance score for *Pea Soup*: http://www.nicolascollins.com/texts/PeaSoupInstructions.pdf.
[20] The current version of the program can be downloaded here: http://www.nicolascollins.com/software/peasoupmac.zip.
[21] *Pea Soup To Go* went live in October 20011. See http://www.nicolascollins.com/peasouptogo.htm.

ATTACHMENTS

Attachment 1:
Partial schematic of Sony TC152-SD Cassette Recorder, showing feedback-friendly microphone preamplifier and limiter.

Attachment 2:
Data sheet for Electro-Voice 635a microphone.

Attachment 3:
Brochure for Countryman Model 968 Phase Shifter (c. 1974.)

Attachment 4:
Circuit diagram for Countryman Model 968 Phase Shifter, with email correspondence with Carl Countryman that led to my being faxed the schematic (1996.)

Attachment 5:
Phase shifter circuit by Norman Doyle from *Electronic Design*, March 15, 1969.

TC-152SD

USA Model

PORTABLE STEREO CASSETTE-CORDER

SPECIFICATIONS

Power Requirements: AC 120 V, 60 Hz, 12 W
DC 6V, four size "D" flashlight batteries or SONY rechargeable battery pack BP-8 or SONY car battery cord DCC-128

Track System: Four-track two-channel stereo

Tape: SONY high quality cassettes (C-60 HF, C-90 HF, C-120 HF), SONY chromium dioxide cassette (C-60CR) or equivalent

Tape Speed 4.8 cm/s ($1\frac{7}{8}$ ips)

Recording Time: 2.0 hrs total (with cassette C-120)

Frequency Response: NAB
30~15,000 Hz with chromium dioxide cassette
30~13,000 Hz with ordinary cassette

Signal-to-Noise Ratio: DOLBY NR OFF 48 dB
DOLBY NR ON
improved 5 dB at 1 kHz and improved 10 dB at 5 kHz and above

Wow and Flutter: NAB 0.15 % RMS (weighted)

Record Bias Frequency: Approximately 105 kHz

Power Output: 1.5 W (AC operation)
(at 10% Distortion) 0.8 W (DC operation)

Inputs: MICROPHONE (two)
Impedance: low impedance
Maximum sensitivity: −72 dB (0.2 mV)
LINE IN (two)
Impedance: 100 kΩ or more
Maximum sensitivity: −22 dB (60 mV)

Outputs: LINE OUT (two)
Impedance: 10 kΩ or more
Output level: 0 dB (0.775 V)/100 kΩ
HEADPHONE
Impedance: 8 Ω
Output level: −28 dB (31 mV)

Semiconductors: 40 transistors, 4 IC's and 35 diodes

Motor: D-009F

Speaker: 100 mm (4 inch) dia PM dynamic, 8 Ω

Record/Playback Head: PF145 - 3602A

Erase Head: EF135 - 36

Dimensions: 378 (w) × 108 (h) × 238 (d) mm
$14\frac{7}{8}$ (w) × $4\frac{1}{4}$ (h) × $9\frac{3}{8}$ (d) inches

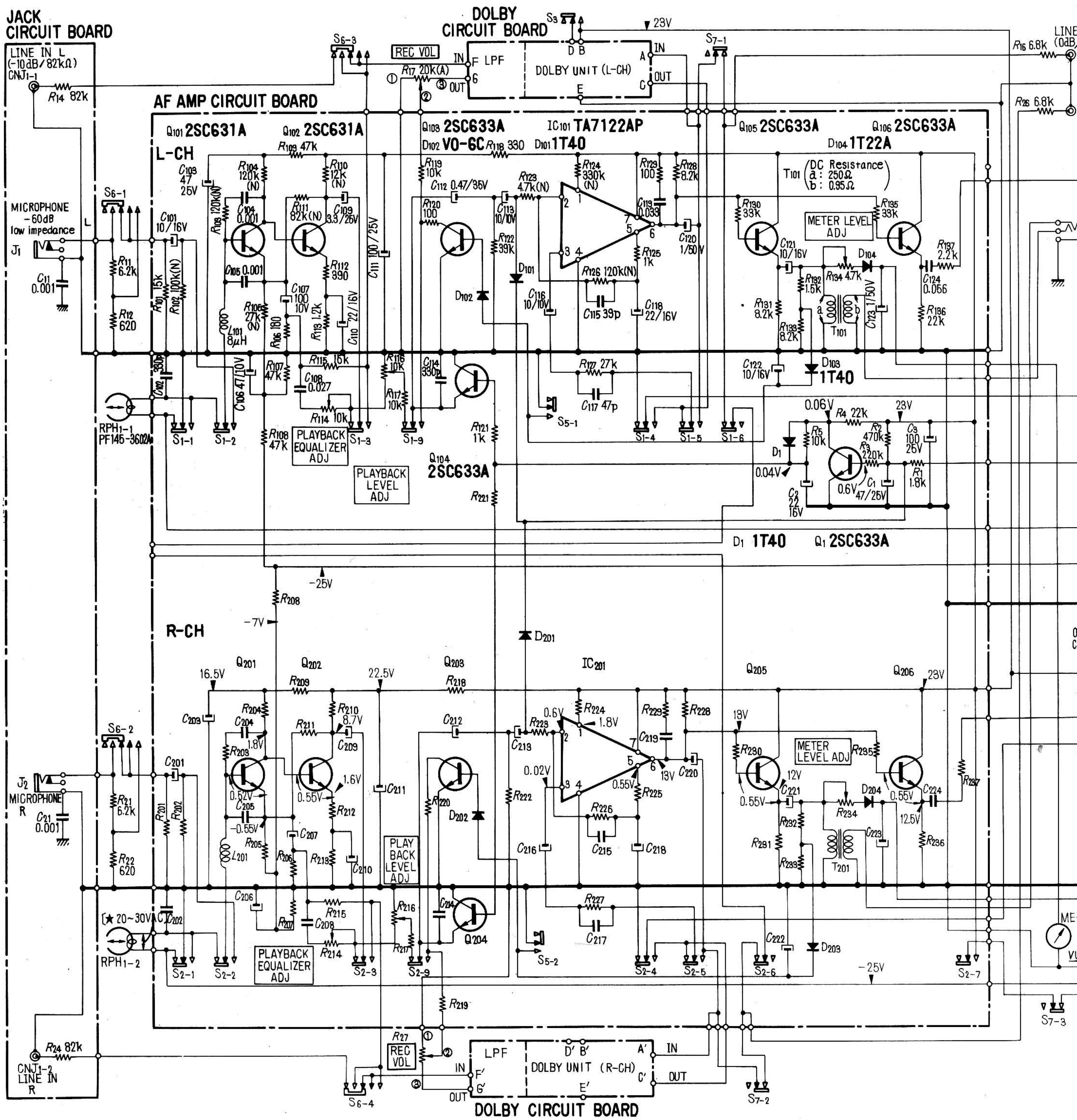
Weight: 5.4 kg, 11 lb 15 oz with batteries

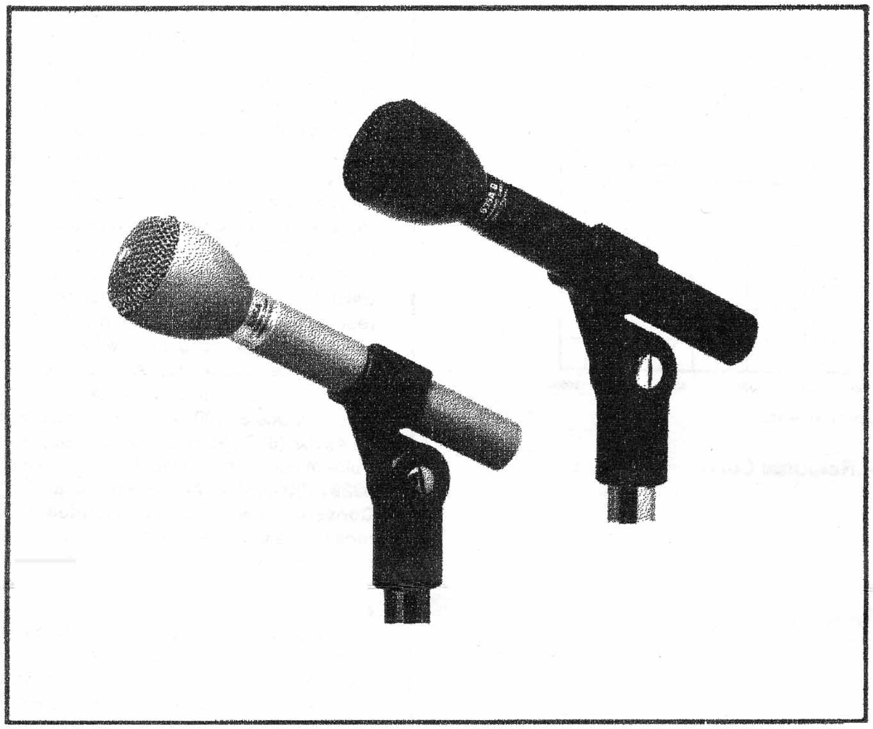
SONY®

SERVICE MANUAL

SECTION 4
DIAGRAMS

4-1. SCHEMATIC DIAGRAM





Electro-Voice®
a MARK IV company

Models 635A 635A/B Dynamic Omnidirectional Microphone

SPECIFICATIONS
Element:
Dynamic
Frequency Response:
80-13,000 Hz
Polar Pattern:
Omnidirectional
Impedance:
Low (150 ohms)
Output Level:
-55 dB
(0 dB = 1 mW/pascal)
Case Material:
Steel
Dimensions:
151 mm (5.94 in.) long,
36 mm (1.41 in.) diameter
Finish:
635A/B Semi-gloss black
635A Fawn beige
Accessories Included:
Model 311 stand adapter—not included in six pack
4.6 m (15 ft), 2-conductor shielded broadcast type synthetic rubber—jacketed with Switchcraft A3F connector.
Optional Accessories:
307 shock mount
313 stand clamp
314E windscreen
340 security clamp
342 security stud mount
Net Weight:
170 grams (6 oz.)
Shipping Weight:
635A/B: 454 grams (16 oz.)
635A/B Six Pack: 1.64 Kg. (58 oz.)
Package Size:
635A & 635A/B:
133.4 mm (5.25 in.) wide,
76.2 mm (3.0 in.) high,
241.3 mm (9.5 in.) long
635A & 635A/B Six Pack:
355.6 mm (14 in.) wide,
215.9 mm (8.5 in.) high,
152.4 mm (6 in.) long

DESCRIPTION AND APPLICATIONS
The Electro-Voice 635A and 635A/B are designed for exacting professional applications such as film production, recording, FM, AM, and TV broadcasting and the more demanding PA applications.

The 635A and 635A/B may be purchased in packages of six. These "six packs" do not include the stand adapter or cable.

The high output level, and low sensitivity to mechanical shock, make the 635A and 635A/B excellent for interviews and for pass-around use in audiences.

The 635A and 635A/B feature a diaphragm which permits very smooth response over a wide frequency range. The diaphragm withstands humidity and temperature extremes, corrosive effects of salt air, and severe mechanical shocks. It is practically indestructible with normal use.

A four-stage pop and dust filter insures a completely pop-free performance and virtually eliminates an external windscreen for outdoor use.

An internal shock absorber effectively reduces the pickup of cable and other noise generated by external contact.

ARCHITECTS' AND ENGINEERS' SPECIFICATIONS
The microphone shall be an Electro-Voice Model 635A or 635A/B. The microphone shall be an omnidirectional dynamic type with wide range response uniform from 80 to 13,000 Hz. It shall have a four-stage pop filter, and magnetic shield to prevent dust and magnetic particles from reaching the diaphragm. The impedance shall be such that the microphone will match 50-, 150- and 250-ohm inputs. The line shall be balanced to ground and phased.

The output level shall be -55 dB with 0 dB equalling 1 mW/pascal. The magnetic circuit shall be a non-welded circuit and employ Alnico V and magnetic iron. The case shall be made of steel.

The microphone shall have a maximum diameter of 36 mm (1.41 in.), a length of 151 mm (5.94 in.) and a weight of 170 grams (6 oz.). The microphone shall have a built-in connector similar or equivalent to the Switchcraft A3M.

The Electro-Voice Model 635A and 635A/B are specified.

WARRANTY (Limited)
Electro-Voice products are guaranteed against malfunction due to defects in materials or workmanship for a specified period, as noted in the individual product-line statement(s) below, or in the individual product data sheet or owner's manual, beginning with the date of original purchase. If such malfunction occurs during the specified period, the product will be repaired or replaced (at our option) without charge. The product will be returned to the customer prepaid. **Exclusions and Limitations:** The Limited Warranty does not apply to: (a) exterior finish or appearance; (b) certain specific items described in the individual product-line statement(s) below, or in the individual product data sheet or owner's

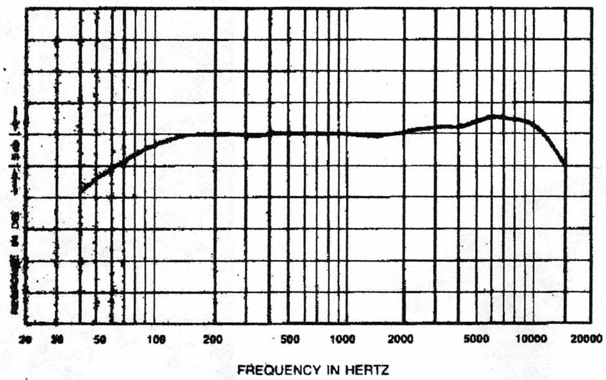


FIGURE 1 — Response Curve

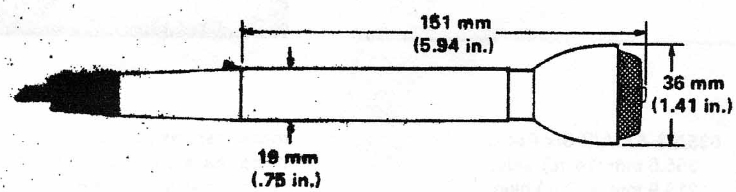


FIGURE 2 — Dimensions

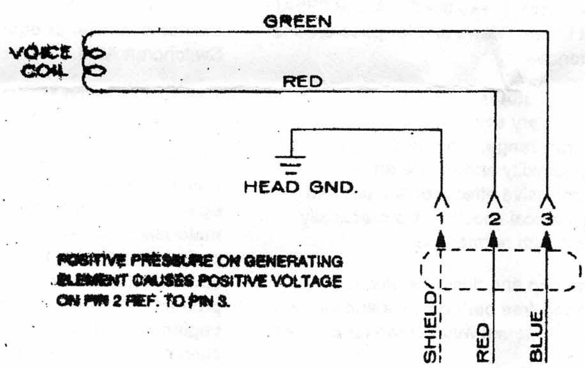


FIGURE 3 — Wiring Diagram

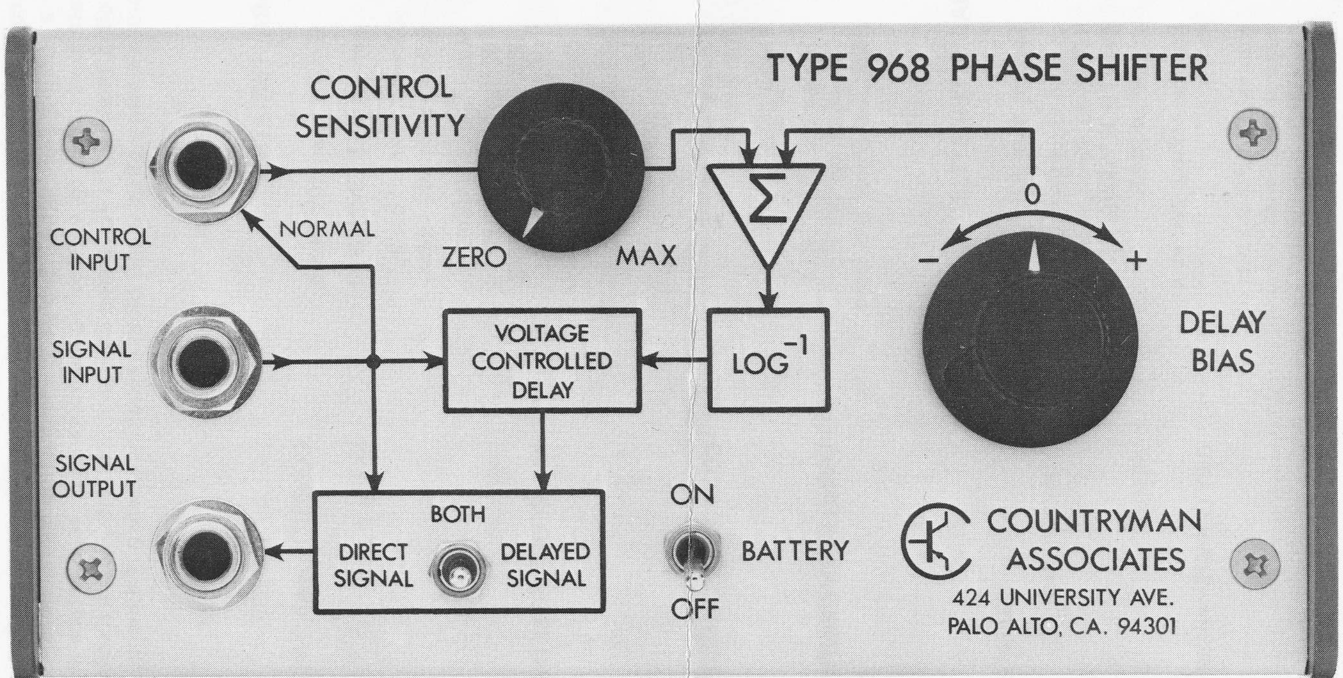
WARRANTY (Limited)
(continued)

manual; (c) malfunction resulting from use or operation of the product other than as specified in the product data sheet or owner's manual; (d) malfunction resulting from misuse or abuse of the product; or (e) malfunction occurring at any time after repairs have been made to the product by anyone other than Electro-Voice or any of its authorized service representatives. **Obtaining Warranty Service:** To obtain warranty service, a customer must deliver the product, prepaid, to Electro-Voice or any of its authorized service representatives together with proof of purchase of the product in the form of a bill of sale or receipted invoice. A list of authorized service representatives is available from Electro-Voice at 600 Cecil Street, Buchanan, MI 49107 (616/695-6831) and/or Electro-Voice West, at 8234 Doe Avenue, Visalia, CA 93291 (209/651-7777). **Incidental and Consequential Damages Excluded:** Product repair or replacement and return to the customer are only remedies provided to the customer. Electro-Voice shall not be liable for any incidental or consequential damages including, without limitation, injury to persons or property or loss of use. Some states do not allow the exclusion or limitation of incidental or consequential damages so the above limitation or exclusion may not apply to you. **Other Rights:** This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Electro-Voice N/D, PL, BK, and Professional Microphones are guaranteed against malfunction from any cause for two (2) years from the date of original purchase. In addition, the Limited Warranty for the acoustic system contained in these microphones shall apply for the life of the product, defined as a period of ten (10) years from the date that the manufacture of the specific microphone has been discontinued. Any and all active electronics incorporated in these microphones are guaranteed against malfunction due to defects in materials or workmanship for a period of three (3) years from the date of original purchase. The Limited Warranty does not extend to cables, cable connectors, or switches. Additional details are included in the Uniform Limited Warranty statement.

ELECTRO-VOICE, INC., 600 Cecil Street, Buchanan, Michigan 49107
MANUFACTURING PLANTS AT ■ BUCHANAN, MI ■ NEWPORT, TN ■ SEVIERVILLE, TN ■ OKLAHOMA CITY, OK ■ GANANOQUE, ONT.

■ Litho in U.S.A. Part Number 531875 — 206
a MARK IV company


TYPE 968 PHASE SHIFTER
CONTROL SENSITIVITY
ZERO
MAX
NORMAL
CONTROL INPUT
SIGNAL INPUT
SIGNAL OUTPUT
Σ
0
−
+
DELAY BIAS
VOLTAGE CONTROLLED DELAY
LOG⁻¹
BOTH
DIRECT SIGNAL
DELAYED SIGNAL
ON
OFF
BATTERY
COUNTRYMAN ASSOCIATES
424 UNIVERSITY AVE.
PALO ALTO, CA. 94301

TYPE 968 PHASE SHIFTER

The **TYPE 968** is an electronically controllable audio delay line. Used alone, the **968** can produce reel flanging and phase cancellation effects which can be controlled manually or can automatically track the level of the audio signal being flanged. Used in conjunction with an audio console or electronic music synthesizer it can duplicate the doppler frequency shifts from a rotating horn organ speaker, move a sound source in stereo as a function of its changing level, add random phase modulation to synthesized instruments or echo return signals to add subjective depth, produce voltage controlled phase shifts for stereo and quad syntheses, add tremolo to fixed pitch instruments or recorded tracks, and provide many other useful effects requiring phase or frequency modulation of an audio signal.

SIGNAL CHARACTERISTICS

INPUT IMPEDANCE:	Greater than 10k Ohms.
OUTPUT IMPEDANCE:	Less than .5 Ohms @ 1kHz.
CLIPPING LEVEL:	Greater than +12dBm loaded with 600 Ohms.
DISTORTION:	Max. THD @ 0dBm, 100Hz, 1kHz, 10kHz: .05% DIRECT SIGNAL .1% BOTH SIGNALS .2% DELAYED SIGNAL
FREQUENCY RESPONSE:	3dB down at 25Hz and 25 kHz.
OUTPUT NOISE:	Less than −85dBm. (25Hz to 25kHz Measurement Bandwidth)
GAIN:	Unity ± 1dB.
SIGNAL CONNECTIONS:	Unbalanced, RTS jacks with signal on the Tip. Ring and Sleeve grounded.

CONTROL CHARACTERISTICS

INPUT IMPEDANCE:	Greater than 47k Ohms.
INPUT SENSITIVITY:	.5 Volt drives delay from 100uS to 30mS with CONTROL SENSITIVITY pot set at MAX.
INPUT POLARITY:	Positive voltage decreases delay.
DELAY BIAS RANGE:	Equivalent to ± 2 Volts of control input with CONTROL SENSITIVITY pot set at MAX.
DELAY RANGE:	From 100uS to 30mS.
CONTROL BANDWIDTH:	1kHz small signal with static delay at 1mS.
SLEW RATE:	.5mS/1mS of delay when delay is decreasing. 10mS/1mS of delay when delay is increasing. Measured from .5mS to 1.5mS of delay.
ENVELOPE FOLLOWER:	Audio from SIGNAL INPUT connector is rectified with positive polarity, then averaged with a 1mS attack time and a 100mS release time.
CONTROL CONNECTION:	TS jack with Envelope Follower output normal to Tip when no plug is inserted.
MANUAL OPERATION:	With the CONTROL SENS. pot set to ZERO, delay can be adjusted with the DELAY BIAS control.

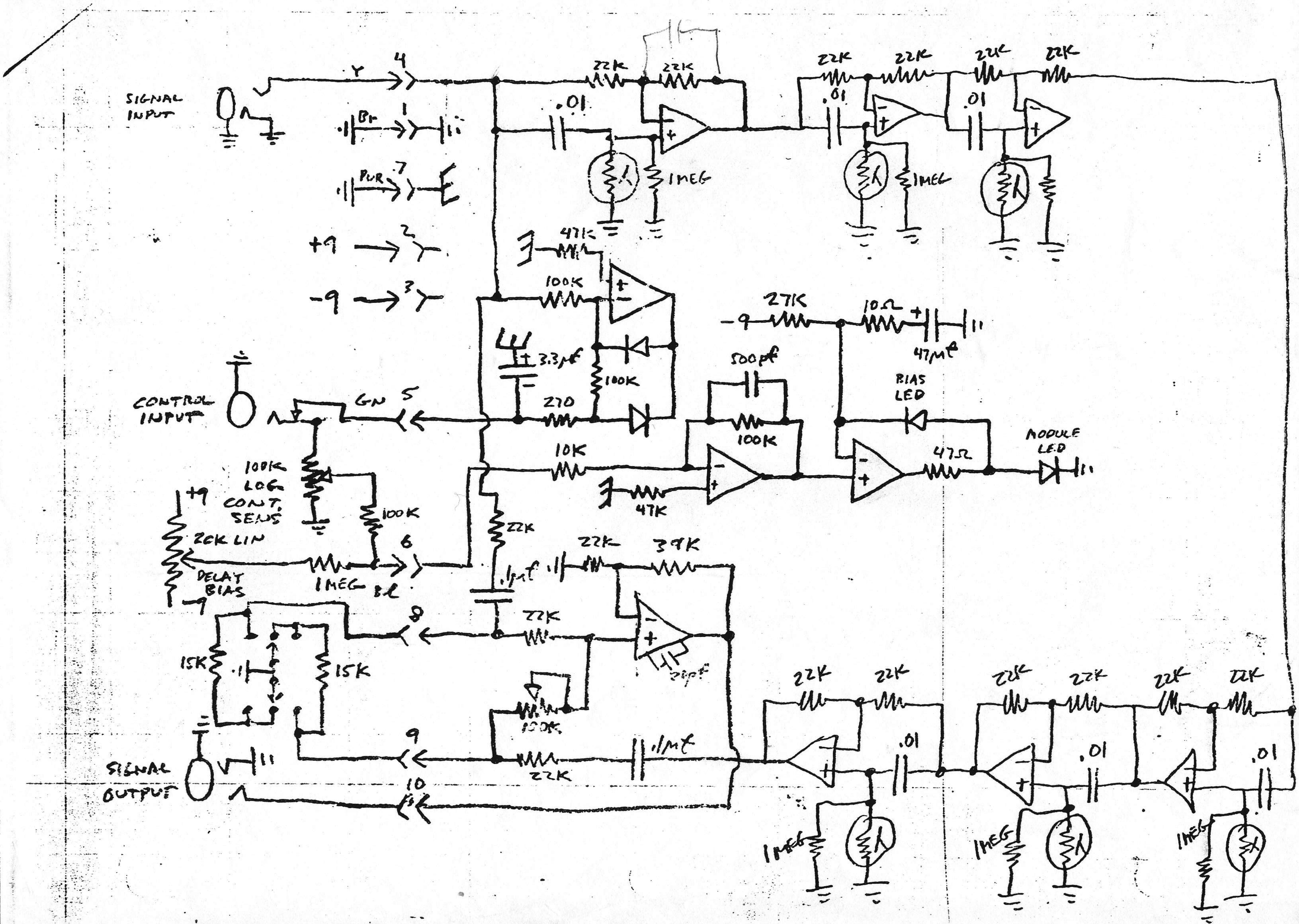
GENERAL DATA

DIMENSIONS:	3 1/2" (8.9cm) High 7" (17.8cm) Wide 6 1/4" (15.9cm) Deep
WEIGHT:	3 1/8 lb (1.43kg) With Batteries.
BATTERY TYPE:	Two 9V Burgess D6, RCA VS306, Eveready 276 or NEDA 1603. One set of batteries is supplied.
BATTERY LIFE:	Approx. 200 Hours.

COUNTRYMAN ASSOCIATES

424 UNIVERSITY AVE., PALO ALTO, CALIF. PHONE (415) 326-6980

968 CIRCUIT



SIGNAL INPUT
CONTROL INPUT
SIGNAL OUTPUT
Y
4
Br
1
PUR
7
+9
2
-9
3
GN
5
6
8
9
10
22K
.01
1MEG
47K
100K
3.3µf
270
27K
10Ω
47Mf
500pf
BIAS LED
MODULE LED
47Ω
10K
100K LOG CONT. SENS
26K LIN
DELAY BIAS
1MEG
Bl
39K
.1µf
15K
.1
22pf
100K

Date: Mon, 29 Jan 1996 16:51:56 -0800 (PST)
From: Carl Countryman <carlc@crl.com>
To: nicc@xs4all.nl
Subject: Re: ghosts of phase shifters (fwd)

---------- Forwarded message ----------
Date: Sat, 27 Jan 96 19:32 PST
From: Carl Countryman <carl@countryman.com>
To: Carl Countryman <carlc@crl.com>
Subject: Re: ghosts of phase shifters (fwd)

Hi Nicolas

We don't have any more phasers or parts but if you email me your address
and promise not to ask for tech support to help you build them, I will send you
the circuit.

Carl >
>
>---------- Forwarded message ----------
>Date: Fri, 26 Jan 1996 10:23:47 +0100
>From: Nicolas Collins <nicc@xs4all.nl>
>To: Carl Countryman <carlc@crl.com>
>Subject: ghosts of phase shifters
>
>Dear Mr. Countryman:
>
>In the mid 1970's, when I was a composition student of Alvin Lucier at
>Wesleyan University, I composed a piece that depended on three of your
>Phase Shifters (they were used to vary the pitch of audio feedback). Over
>the past two decades I've bought and built several phase shift circuits in
>an attempt to re-create aspects of that piece in other compositions, but
>none have had the right behavior or sound quality. At an AES convention
>some years back I asked you if you had any left in the dustier corners of
>your stockroom; you laughed, as I recall.
>
>Well, I'm still in pursuit. I've posted "wanted to buy" notices with a few
>newsgroups, but I thought I'd approach you one more time (please forgive my
>directness.) Are you sure that you have none, working or dead, that you'd
>be willing to sell? If not,is there any chance you would be willing to send
>me a copy of the circuit schematic such that might hand-wire three or
>four? For my own use only, of course, and I would be very happy to sign
>any non-disclosure agreement.
>
>In closing let me mention I am no mere Luddite. I've bought, used, and
>recommended most of your subsequent products. But for me as a composer your
>Phase Shifter remains a musical holy grail. With many thanks for your
>attention, I remain,
>
>Sincerely,
>
>Nicolas Collins
>
>
>
>
>

To: carlc@crl.com (Carl Countryman)
From: nicc@xs4all.nl (Nicolas Collins)

Dear Mr. Countryman:

You may recall that we had some contact a few months ago regarding your fine old phase shifters -- now sadly no longer in production. You offered to send me schematics & documentation in exchange for not bothering you any more. Well, perhaps things have been too busy for you, or you've reconsidered your offer, or something got lost in the mail, but I've yet to receive anything or to hear back through this email aether.

Tragically, this puts me in the position of bugging you indeed. I'll give it another shot (I *really* want to get started on this project). I'll be in the USA April 15-21. If it's easier & cheaper to send the documents domestically rather than to Holland you could mail them to me c/o Trace Elements Records, 172 East 4th Street #11D, New York, NY, 10009. If they arrive after I've left they will be forwarded.

Many thanks once again for the help. I look forward to hearing from you.

Sincerely,

Nicolas Collins

X-Length: 000005b5
Status: N
Date: Thu, 30 May 96 10:30 PDT
X-Sender: carlc@nanospace.com
X-Mailer: Windows Eudora Version 1.4.4
To: nicc@xs4all.nl (Nicolas Collins)
From: carlc@countryman.com (Carl Countryman)
Subject: Re:

Hi Nicholas!

Sorry I forgot to send you the phaser circuit. It will go out today.

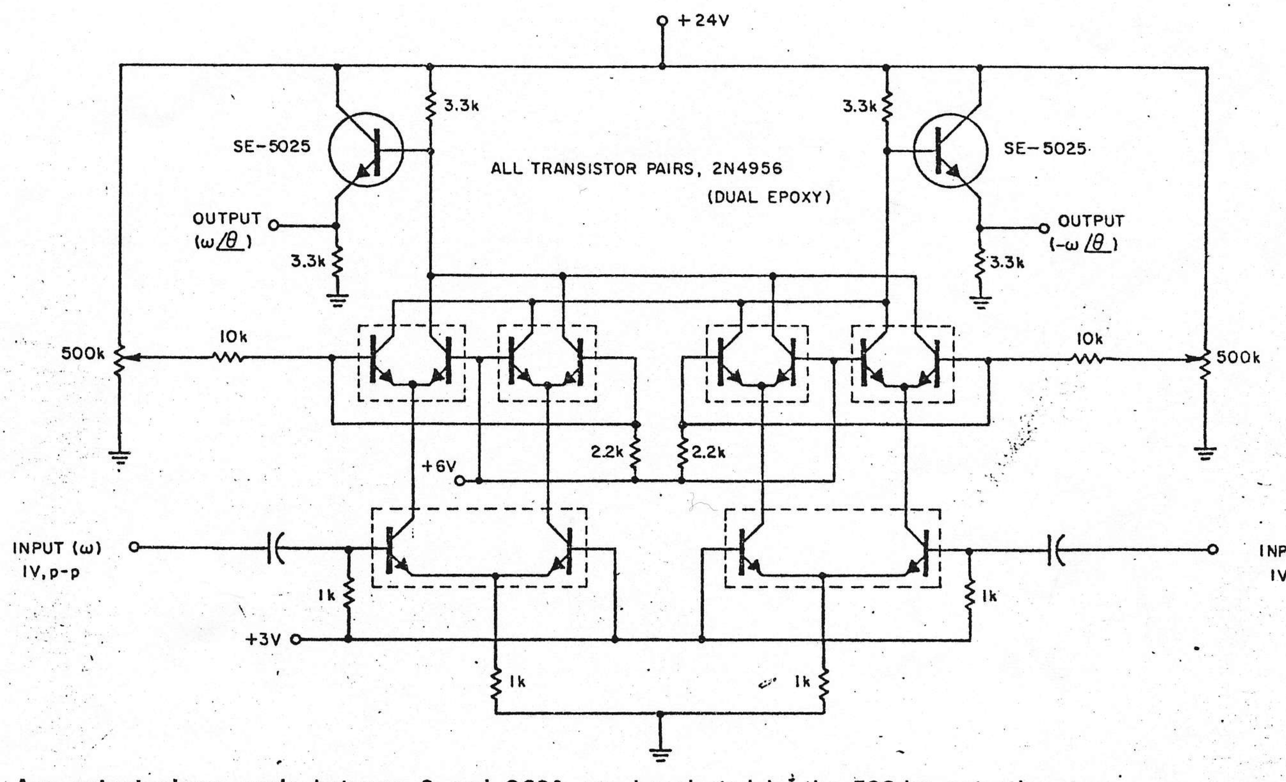
>Dear Mr. Countryman:
>
>Back in January, in response to an email query, you kindly offered to send
>me schematics and documentation on the phase shifters you manufactured in
>the 1970's. I really don't mean to bug you, but I have yet to receive the
>information or any response to my follow-up emails. Are you getting my
>messages? Have you reconsidered your offer?
>
>Gratefully,
>
>Nicolas Collins
>Palestrinastraat 10-II
>1071LE Amsterdam
>NETHERLANDS
>
>
>
>

Carl Countryman
Chief Engineer
Countryman Associates, Inc.
417 Stanford Ave.
Redwood City, CA 94063-3422
Phone (415)364-9988
Fax (415)364-2794
carl@countryman.com

360° video phase shifter uses no transformers

Continuously variable phase-shifting of video-frequency signals over a range greater than 90 degrees usually involves complicated transformers or switching sequences. A much simpler technique, using double-balanced modulators, can provide a continuously variable phase-shifting range of 360° without requiring inductive or mechanical components.

The circuit consists of two double-balanced modulators, with their outputs paralleled. The frequency, ω, whose phase is to be shifted, is applied at one input, and the same signal, shifted in phase by 90°, is applied to the other input.



Any output phase angle between 0 and 360° can be selected by the 500-kΩ potentiometers.

The signal currents thus available for mixing in the output loads represent ω, $\omega\angle 180$, $\omega\angle 90$ and $\omega\angle 270$. The amount of each of these currents that are added is determined by the imbalance introduced by the two 500-kΩ potentiometers. Therefore any output phase angle between 0° and 360°, at an amplitude between zero and 10 V peak-to-peak, can be selected by the proper combination of the potentiometer settings.

If the potentiometers are mounted in a "joystick" arrangement, as is used on some oscilloscopes for trace shifting, the joystick attitude can be made to represent the phase and amplitude of the output frequency.

With the use of matched pairs of a suitable transistor, the circuit functions well over the video-frequency range.

Norman Doyle, Design Engineer, Fairchild Semiconductor, Mountain View, Calif.

VOTE FOR 424

Electronic Design 6, March 15, 1969 pp 254+256