NEUMANN
the history of
Tube Condenser Microphones

by Winn Schwartau and David Smith

From private conversations with Stephen F. Temmer, President, Gotham Audio

This is the story of the youngest of some 12 children born in 1898 to a railroad worker and his wife in the Berlin suburb of Chorin, Germany.

This is about a man of very few words; the virtual father of the modern day condenser microphone; of his apprenticeships, his inventions, his triumphs, the factories built and burned, his hand-built tools for lack of availability, and his career's culmination as an international pioneer in modern technology.

It is about Georg Neumann and the developmental history of the vacuum tube condenser microphone.

The early wireless industry of Germany, after the turn of the century, was largely dominated by two electro-conglomerates; A.E.G. (Associated Electric Industries) and Siemens. Germany was the world leader in theoretical physics and technological applications. Georg Neumann gained his first professional electro-acoustic experience by landing a job with A.E.G. in 1923.

A.E.G. was involved in various areas of electro-acoustic research, and Georg Neumann began an apprenticeship with a Mr. Reisz at A.E.G. Reisz was pursuing improvements in carbon-granule microphones; the basis for telephone transmission. Carbon-granule microphones had severe response linearity problems and Neumann set to work investigating them. After much research, his first major contribution to Reisz's work was the determination and isolation of the linearity problem: acoustical resonances. His subsequent solution was the ability to actually measure and control the resonances for optimum linearity performance. This breakthrough resulted in the Reisz microphone; a carbon-granule microphone built into a hollowed out chunk of marble. Marble was chosen as the support structure for the transducer because it would not vibrate in sympathy with the carbon granules inside, thus eliminating many of the microphone's prior limitations. Neumann also worked on magnetic cutterheads, turntables, and cartridges. These studies and his early interest in cutting lathes would later make Neumann a leader in more fields than just microphones.

While still at A.E.G. with Reisz, Neumann began his pioneering work on using condensers as microphone transducers rather than the conventional carbon.

Neumann's first attempt at a condenser capsule for commercial use was the CM-3. The CM-3 was a pressure transducer (omni) capsule, but it was not until 1930 that an amplifier unit was designed and built: the CMV-3. In 1928, however, Neumann left A.E.G. and Reisz with Erich Rickmann, to form *Georg Neumann and Company*, and that's where the subsequent CM series of microphones and capsules were developed.

At the time, 1930, there wasn't a recording industry as we know it. There was though, a very large, powerful and expanding broadcast industry which demanded the best technology available. In 1930 after the CMV-3 was developed, Telefunken, a subsidiary of A.E.G. and Siemens, took on the marketing rights to Neumann's microphone and sold it under the Telefunken number SO-16.

Neumann's first factory was in Berlin, Germany.

By 1932, Neumann had developed a series of plug-in heads for the CMV-3. Re-named the CMV-3a, or "The Neumann Bottle," it could take either the CM-7, Figure 8 head, the CM-8 cardioid, or the CM-9 omni form.

Georg Neumann 1898-1976

This was the first directional microphone made and utilized the first successfully manufactured double membrane capsules conceived by Braunmuhl and Weber, patented in Germany in 1927. Among his other early works, Neumann in 1931 built and marketed the AM31 cutting lathe, still in use today. He further patented in 1934, the first linear motion pen recorder, predecessor of the modern strip recorder and X-Y plotter.

While his company was manufacturing microphones which were being marketed as Telefunkens, Neumann began to re-pursue an interest which had intrigued him for some time. During much of World War II, in his Gefell factory, Neumann continued a line of research well out of his field; Chemical Engineering. He wanted to create a sealed storage cell which could be easily recharged. By the end of World War II, Neumann had not yet perfected his sealed NiCad battery, much of his factory in Berlin was in ruins, and there were few people interested in quality microphones. An old friend, by the name of Gottesmann, knew of Neumann's work and wanted to see him continue. Gottesmann talked to French officials, who also knew of Neumann's work, so almost immediately after the cessation of hostilities in Europe, he was set up in a laboratory in Paris. He was able to complete the most important invention of his life and one of the few basic patents of this century: The gas tight rechargeable Nickel Cadmium Battery.

Georg Neumann's factory in Gefell was still intact and in the American Zone of Germany. But the Gefell region was ultimately ceded to the Russians in exchange for access routes to Berlin at the Potsdam Conference attended by Churchill, Stalin, and Truman. So Neumann left for Berlin in 1947, where he began the tedious process of re-tooling his old manufacturing company. The Gefell factory continued manufacturing Neumann microphones and Georg Neumann went to Gefell quite often to help their production efforts. They continued to use the original trademark used for so many years prior by Neumann, and he, himself, continued to use the same trademark in his Berlin factory, except enclosing it within the now famous diamond signature.

Gotham Audio, in fact, owns the trademarks for both the Gefell Neumann and the Neumann GmbH Berlin to insure against the East German microphones entering the country today.

(The Neumann trademarks are also useful to identify tube or transistor microphones. The diamond background is black for tubes and purple for solid state.)

In 1947 there was still a minimum of redeveloped German industry, so Neumann's personal machinist, Mr. Rehagen, who had been with him in Gefell and Paris, built from scratch the precision equipment needed to construct everything from wind screens to the tensioning mounts for the capsule membranes.

What first came off the production line in June 1948 has become the subject of intense debate and equally intense monetary appreciation: the immortal U47.

A CHRONOLOGICAL HISTORY OF NEUMANN VACUUM TUBE CONDENSER MICROPHONES FROM 1947 - 1967

U47 and U48

The Neumann U47 was originally marketed by Telefunken, the only post-war company able to actually properly handle the product on an international basis. In fact, much of German electrical manufacturing was distributed by the now wholly owned subsidiary of A.E.G. This is why many of the engineers today refer to the U47 as a "Tele."

The first microphones off the assembly line were the finest mikes of their day, though today we would call hand wire wound resistors made on a base of packing cardboard rather crude. The 32 mm gold sputtered PVC based diaphragm (K47) was a Braunmuhl-Weber dual membrane design housed in a hand tooled head and grill (KK-47). There were two pins connecting the head to body which carried signal and polarizing voltage to the diaphragms.

The preamp used was a simple as amps get. A metal encased glass pentode wired as a triode with cathode feedback for gain coupled to either a fifty or two hundred ohm output impedance, strappable transformer, provided the necessary matching circuitry to talk to other equipment. Because there was no post-war tube manufacturing yet in Germany, a prewar pentode was selected; the Telefunken VF-14. The VF-14 was a radio tube from the 1930s and employed a 55 volt filament. The highly microphonic VF-14 was mounted in a shock mount within the microphone body and the hand wound 1780-ohm filament resistor dropped the filament voltage to 37 volts. The lowered filament voltage insured an exceptionally long life for the tube, superbly quiet operation and a hand-warming body.

Original U47s had hand engraved Neumann insignias on the body and were some 3" longer than those produced in later years. The separate power supply provided 105 volts for 60 V polarizing voltage and the directly heated cathode on the VF-14.

Between June 1948, when the U47 was introduced, and June 1951 only 500 microphones were produced. By the time serial #3100 U47 was manufactured, in 1956, the body size was reduced from the long body tube with chrome head, to the smaller body tube and matte finish head. That same year, Neumann introduced the U48; different from the U47 in that it produced the cardioid or Figure 8 pattern rather than a choice of cardioid or omni.

To produce an accurate Figure 8 pattern, the front and rear diaphragms had to be matched exactly for frequency response and capacitance. The rejects of K47 capsules were often caused by a phenomenon known as "electret." An electret is a permanently polarized diaphragm. Simple enough. We know very well how to produce one, then and today; but we don't know why the diaphragm holds the charge, or as in Neumann's case, how to avoid it in production.

The U48 head had three pins to carry the out-of-phase split polarizing voltage of 52½ volts to each diaphragm. Later marketing techniques would sell U48 bodies with U47 heads, to provide the customer with the option of plugging a U48 head into the body when required.

When Telefunken was representing Neumann as an international distributor, the U.S. sales agency was American Elite, operating from a store front on Park Avenue and 34th Street, in New York City. One of their salesmen, Fred Cunow, was trying to sell a U47 to a tough customer, Stephen Temmer, then president of Gotham Recording. Temmer finally acquiesced in 1953 and purchased the overpriced U47 for $390.00. (The next highest priced microphone on the market was the RCA 77D at $135.00.) Temmer used this sole mike shortly thereafter to mix an entire orchestra and vocal group, The Ink Spots. A subsequent article by Temmer stated . . . "from now on we'll never need more than one microphone."

Temmer's only complaint from the microphone was its overload characteristics, as the dynamic range was limited to 108 dB. He and an engineer from Gotham redesigned the amplifier and changed it from a triode stage to a cathode follower. Temmer changed the U47s

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ENGINEERING THE CAPACITIVE MICROPHONE CAPSULE

Winn Schwartau and
David Smith

All microphones are electro-mechanical transducers which convert acoustical energy into electrical energy. A condenser (capacitor) microphone is essentially a capacitor with one fixed plate and one suspended plate which is free to vibrate in sympathy with acoustical vibrations impinging upon it.

The capacitance between the two electrodes (typical spacing .0015" [0.04 mm] or less) will vary as the freely suspended plate, known as the diaphragm moves with respect to the fixed electrode. If there is a potential difference (voltage) applied across the two plates, through a very high resistance, the charge on the plates will remain constant.

Equation #1:

$$E = q/c$$

E = voltage
q = charge
c = capacitance

Thus, as the capacitance changes with the impinged sound waves, and as the charge is held constant, the output voltage will vary inversely with the capacitance. For this varying voltage to be useful in audio, the output must be amplified. But because we are in a very, very high impedance circuit ($>10^9$ ohms), which is primarily capacitive, an output load must be selected which will not in any way affect or cause the diaphragm to discharge. The ideal output for a condenser or diaphragm is a purely resistive load of very high impedance with no capacitive or inductive loading so as to maintain the constant charge (q) on the diaphragm. In practice, this requisite precludes the use of long wires from the condenser diaphragm, or the inclusion of any other components which can cause inductive loading.

The proper operation and construction of the condenser microphone element is determined by several variables, all of which must be specifically and accurately controlled.

Equation #2:

$$E_{oc} = EPA/4DT$$

E_{oc} = open circuit output voltage
E = polarizing voltage (across plates)
P = applied acoustical pressure in Dyne/cm^2
A = radius of diaphragm in/cm
D = distance between charged plates in cm
T = membrance tension in Dyne/cm

The electrical output signal is quite complex by the number and function of mechanical and electrical parameters which can affect it. The most critical component involved in the microphone is the capsule itself. There are four considerations in its final design.

1 - Tension of the membrane (compliance) determines the low-frequency characteristics of the vibrating membrane. The stiffer the diaphragm is held on its support rings, the greater the low-frequency droop. The low end roll-off is dB/octave and the drop off point is shifted by various degrees of tension.

2 - Mass determines the high frequency response of the diaphragm's movement. As the mass of the diaphragm increases, the high frequency limit decreases. The mass of the diaphragm is affected by a combination of the thickness and composition of the membrane.

3 - The diameter of the head also determines the mass of the membrane, therefore affecting frequency response. Thus, the smaller diaphragm microphones have a different high frequency characteristic than do the large diaphragm microphones.

4 - The spacing between the plates obviously affects the capacitance of the circuit itself. Further and more importantly, the spacing creates an air pocket which acts like a spring cushion to the vibrating mass of the membrane, effectively affecting the system's compliance.

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the authors

David Smith is 30 years old with an MSEE from RPI. He was chief engineer of A&R Recording, in New York, and presently is chief engineer of Phil Ramone, Inc., an independent production company. Dave has been an avid tube microphone collector and now boasts one of the finest and largest private tube microphone collections in the country. His Masters thesis with RPI involved the development of two condenser microphone capsules.

Winn Schwartau is a native of New York City. He got into professional audio in 1969, at the age of 16, at Mirasound Studios. In the following years he has worked in various aspects of the recording industry at a number of prominent New York Studios.

Currently, he is president of Empirical Audio, a New York based engineering firm which is now involved with studio design and installation, custom engineering and brokerage consultation and East Coast distribution of Trident products.

for other studios, but only until 1957 when he went to Berlin and met Neumann's Physicist, Gerhart Bore.

In August 1957, Temmer was taking a trip through Europe and while in Germany he had the opportunity to visit the Neumann factory. The first person to meet Temmer in the waiting room was Dr. Gerhardt Bore, who immediately bristled angrily upon spying the man who changed the U47 circuitry. "How dare you . . .!"

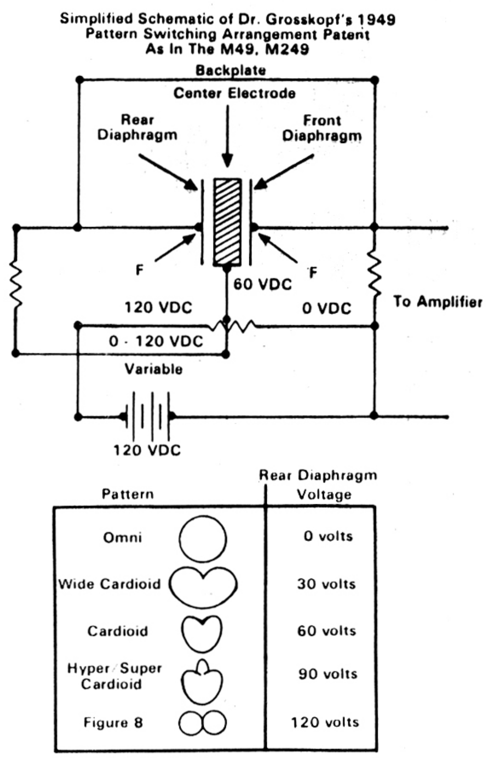
Coincidentally, Neuman had pulled his distributorship from Telefunken as of April 1, 1958, as American Elite was on the verge of bankruptcy. Temmer left Germany with the new stereo SM2 microphone as a gift and the possibility of becoming the U.S. Neumann sales representative. After some immediate success with selling Neumann stereo disk cutting lathes in New York, Temmer set up Gotham Audio Sales Corporation, and began distribution of the already extensive line of Neumann microphones and peripherals. The U47s were re-modified to the original triode preamp and remained that way thereafter.

Since Telefunken no longer sold the U47 or M49, or any other Neumann microphone, and as the U.S. based microphones came into Gotham for repair and overhaul, the Telefunken insignias were summarily changed to the Neumann diamond. Telefunken soon commissioned another microphone manufacturer to produce a microphone to compete with the U47. The manufacturer was AKG. This Austrian-made microphone was marketed by Telefunken as the ELA-M251, the predecessor of the C-12 and 414.

M49, M249, M50, M250

After the war, the German broadcast industry re-grouped and the networks organized and formed the *Institute Fur Rundfunktechnic:* Broadcast Institute Labs, known as the IRT. The IRT is now based in Munich and forms the technical support base for the German broadcast industry. They set standards for all equipment, design equipment, manufacture equipment and set test practices in formal guidelines; in short, nothing goes on the airwaves without having been thoroughly selected and analyzed by the IRT, including every reel of tape.

In the early days of the IRT, it was decided to set standards for and have manufactured a microphone that would meet their stringent requirements. Dr. Herbert Grosskopf, an IRT scientist, was charged with the project and proceeded to design and construct the M49 condenser microphone. The revolutionary leap that Grosskopf made realized a patent in 1949: "A Capacity Microphone with Variable Direction Characteristics" (below). This



was the world's first electrically variable multi-pattern, remote controlled condenser microphone. (Grosskopf in 1952 also developed a mechanical method of changing patterns and the right to manufacture these microphones were given Schoeps.)

The capsule used was Neumann's K48, PVC gold sputtered dual membranes as was used in the U48. The M49 does not resemble any other Neumann microphone because it was designed by the IRT, although Neumann did the manufacturing. The power supply

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ENGINEERING THE CAPACITIVE MICROPHONE CAPSULE

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The manipulation of these variables, in very minute amounts, is the microphone designer's most formidable task. It was Georg Neumann's first professional success: The determination and control of the diaphragm resonant point. The solution found in eliminating, creating, or changing resonance in condenser elements, was the placement of holes through the backplate in very controlled and precise locations to damp or create resonances within the audio range and move others entirely out of it.

Condenser elements (with their associated backplate, known as capsules), built by Neumann or others, fall into three distinct mechanical categories:

1 - The pressure transducer (Figure 1) is a condenser capsule where only one side of the diaphragm is exposed to the sound field. This renders the diaphragm sensitive to pressure variations on its surface regardless of the location of the sound source relative to the capsule. The resultant pickup pattern is "omni-directional," sensitive to incident sound from "all-directions."

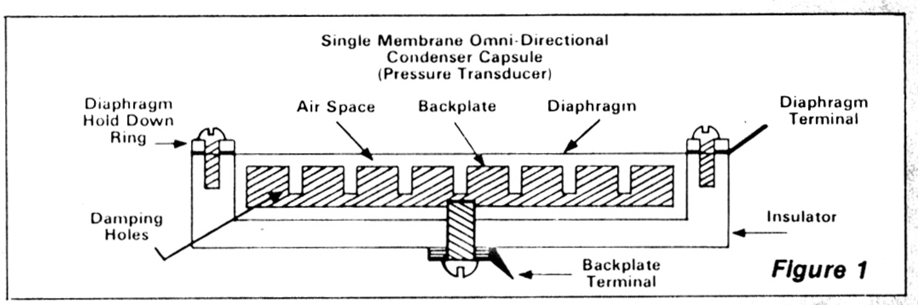


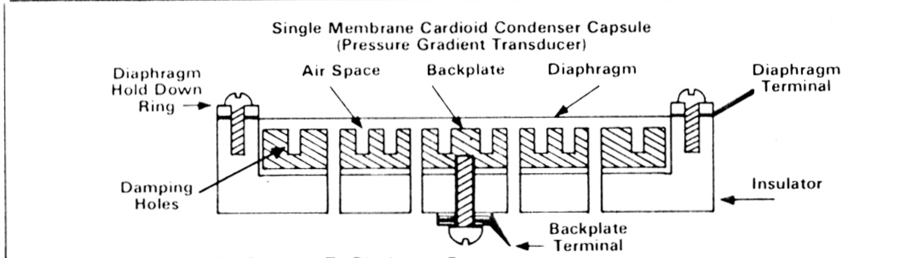
Figure 1

In this, as in all capsules, a metal or metal-coated plastic membrane (less than .001" [0.025 mm] thick) is stretched over a spacing ring and mounted .001" or so from the metal backplate. Perforations are made in the backplate itself to damp out various mechanical resonances, inherent in the physics of the membrane structure.

In the pressure transducer, the back of the diaphragm is airtight, so no acoustical energy reaches the rear of the diaphragm. The perforations in the backplate do not go through it completely to insure complete acoustic isolation.

The pressure transducer is also affectionately known as a fast-acting barometer.

2 - The pressure gradient capsule (see Figure 2) is similar to the pressure transducer, however, it operates on a slightly different principle. The pressure gradient or difference in pressure between the front and rear of the capsule diaphragm is created by admitting some acoustic energy to the rear of the diaphragm by making some of the damping perforations go completely through the backplate. These extended perforations are positioned such that any sound waves coming into the rear of the microphone impinge upon the rear of the diaphragm 180° out of phase from when they strike the front, thereby cancelling themselves. This is otherwise known as a cardioid or uni-directional microphone, responding to sound sources from the front of the capsule and rejecting



Air Passages To Diaphragm Rear — These passages are dimensioned and positioned so as to allow sound impinging on the rear of the capsule to reach the rear of the diaphragm 180° out of phase with the same sound traveling around the capsule and impinging on the diaphragm front thereby cancelling itself

Figure 2

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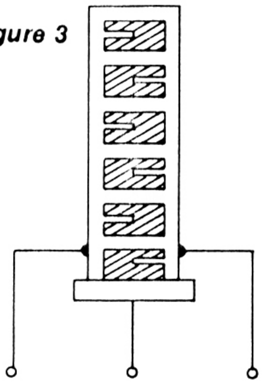
ENGINEERING THE CAPACITIVE MICROPHONE CAPSULE

(continued)

off-axis signals. The degree of uni-directionality is determined by the size, length, and positioning of the perforations in the backplate.

3 - The third type of capsule (see Figure 3) is a dual-membrane capsule with a centrally-mounted backplate, or backplate and acoustic chamber combination. Basically, there are two back-to-back cardioid capsules in a single housing, giving the user a choice of several patterns depending upon the internal electrical arrangement. If the capsule outputs are connected together -in-phase,- an omni-directional pattern occurs. Either one of the capsules may be used to represent the cardioid pattern, or both capsules may be connected out-of-phase with each other, resulting in a third pattern; the figure-8. The figure-8 admits signals from both sides (front and back) of the capsule, but eliminates sources from the sides.

Figure 3



Basic structure of the Braunmuhl-Weber dual capacitor structure. Important features: (1) there are two diaphragms, one on each side of the backplate; (2) there are perforations in the backplate which connect both cavities; and (3) there are holes on both sides of the back plate which provide damping for the diaphragms.

Once we have a linear response from the capsule and a pattern of our choice, we need to make this signal useable and audible. The next stage in any condenser microphone is the preamplifier.

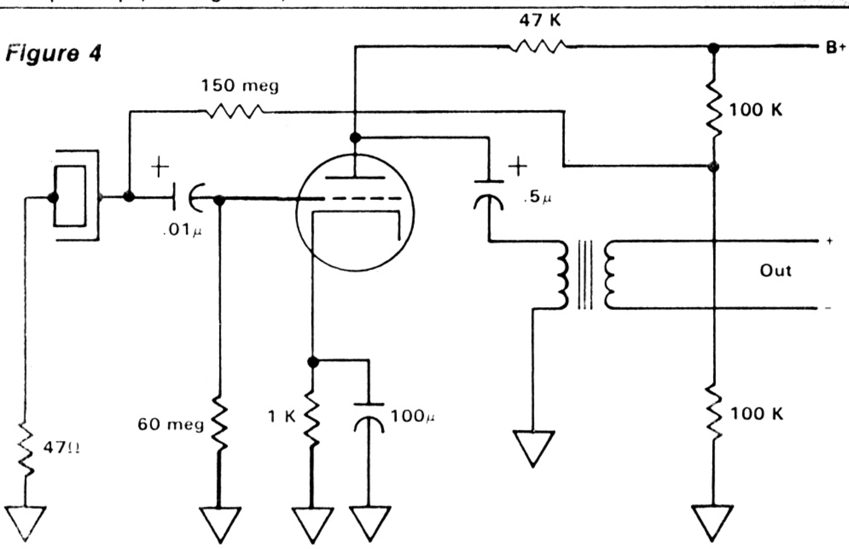
If we had our druthers, what would that that preamp be like? The ideal preamplifier for a condenser element would have:

1 - Infinitely high input impedance.
2 - Purely resistive input impedance.
3 - No internal noise source.
4 - Zero output impedance.
5 - No distortion.
6 - As much or as little gain or loss as desired.

The basic tube preamp used in many condenser microphone designs has been either a cathode-follower or a triode loss stage. Although neither choice reaches the aims of the ideal preamp, it remained basically unchanged until the transition was made to solid state devices.

The basic triode loss stage was used by Neumann throughout, so let's examine a typical preamp (see Figure 4).

Figure 4



B+ is 120 VDC. The voltage divider places 60 volts on the diaphragm. The 100 μf cap is for AC gain.

The preamp is a Class A stage with an input impedance of 60 megohms and a cathode bypass capacitor used for gain. The cathode resistor should be a low noise type as should be the plate resistor. The output transformer is simply for plate-to-line matching and to provide a balanced output audio line to connect to the real world. It should be noted that in 1927, as well as today, the preamplifier in any condenser microphone is the limiting factor for dynamic range, not the capsule.

Georg Neumann had an amazing array of technical problems to surmount in 1927 because a good deal of the previous discussion hadn't yet been discovered. Much of the tooling for the condenser and the manufacturing of the tools themselves had to be done by hand. The state-of-the-art of electronics was still in its infancy, as evidenced for example, by the size of some of the early capacitors; often approaching the size of our mega-micro farad electrolytics today. □ □ □

provided 120 volts which permitted varioı combinations of polarizing voltages on tl diaphragm for a continuous sweep betwe the three basic patterns, while providing aı intermediary patterns such as hyper-cardio and super-cardioid.

The preamp chosen was based around Telefunken triode, the low noise AC701 specially designed for use in condens microphones. The AC701k manufacture hı stopped, but a quantity is still available toda The microphone had some problems, whic were discovered unexpectedly whe recording a live orchestra. The recording wa found to have clicks and pops throughout i Several hair-pulling months later, it was foun the the AC701k was highly light sensitive an even inside the microphone body and blac glass tube case, it would respond t photographic lightbulb flashes. Even toda the AC701k is painted densely black but body shield enclosing the preamp prevent light from entering.

As the clout of the broadcast industry grew manufacturing concerns responded to th requirements and designs of the IRT via th Brown Book, 'the operating standards c German broadcasting.' Germans felt the were building studios to last and things had t be as idiot proof and fail-safe as possible, s new standards arose.

The plug settled on, for example, was a 7-pi Tuchel connector, so the M49 with its 8-pi bayonet connector was rebuilt for th broadcast standard and known as the M249 The prefix "2" refers to the 7-pin connector The prefix "M" referred to the AC701 preamp, which was the only mike preamp tub permitted to be used in broadcast. One furthe modification of the M49/M249 serie microphones was their "b" and "c" version which provided a strap position in the mike t keep the microphone in the cardioid positio at all times, realizing a 6 dB improvement i signal-to-noise ratio. The "e" version provide cathode biasing.

The broadcast industry's desire for a single microphone for orchestral recording saw the development of the M50/M250 microphone. Neumann developed a special capsule for the IRT, a miniature nickel, single membrane pressure transducer mounted into a clear plastic sphere. Because of the spherical casing, the directional characteristics transitioned from omni at the low end and became more uni-directional with increased frequency. Since most orchestra recordings are done at some distance from the sound source, there are high frequency acoustic transmission losses caused by the distance. Consequently, the AC701k preamp had an equalizer which achieved a 5 dB boost function at 2 kHz to compensate for this phenomena. The capsule which was utilized in the M50/M250 microphone was a radical change from the previous K47/48 capsules.

Neumann's special experiences with nickel in his NiCad research provided him with the unique opportunity to answer a new and growing television industry demand.

KM53, KM54, KM55, KM56

The television industry, in its black and white infancy was also required to follow the regulations of the Brown Book. The demand arose for smaller, less visible, high quality microphones of high quality was rising and Georg Neumann answered the call with the KM (*Klein Mikrofon*) small microphone series.

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The 15 mm diameter capsule required a new technology to match prior performance expectation. By using a smaller capsule and desiring to retain a high signal-to-noise ratio, the electrode spacing has to be diminished. Thus, the diaphragm had to be tensioned to limits greater than the PVC used would permit.

The substitute diaphragm material decided upon was nickel, as evidenced in the pioneering work of the M50. The nickel was grown electrolytically on a host base which was thereafter de-plated from the fine sheet of nickel remaining. The nickel sheet was able to be tensioned to the required limits, a new standard in microphones was born and the ever-present broadcaster's AC701k tube was the basis for the preamp. These pure nickel membranes have a thickness of only 0.7 um. It would take 1,428 membranes placed on top of one another to reach a thickness of one millimeter. The KM53 was an omni-directional pressure transducer with a single membrane of nickel. The KM54 was a single membrane also, but in order to achieve its cardioid pattern, an acoustical delay network behind the diaphragm made soundwaves originating from the rear, arrive at the rear of the diaphragm 180° out-of-phase with the same soundwaves arriving in front. The KM55 was a KM54 with slightly additional tensioning of the membrane for bass roll-off, and the KM56, a switchable three pattern unit, was two KM54 capsules back-to-back, effectively duplicating the effects of a dual membrane capsule.

The entire KM and M series of microphones had another novelty in them which was not replaced in design or repair until solid state technology caught up with Neumann's discovery of 20 years prior. In his NiCad research, Neumann had built bad storage cells as well as good ones. One of the NiCad failures was a cell that would not hold a charge, but would begin to pass current above a certain threshold voltage. He called these stabilytes. Stabilytes were 1.5 volt virtually unchargeable NiCads of varying current capabilities and had the filtering effect of 60,000 mf at 60 Hz power line frequency. These were used in all AC701k supplies as filament filtering units. The stabilytes were replaced about 1964 by a complex solid state device.

The crowning achievement of the KM50 series is undoubtedly the KM56 microphone, but Neumann took the KM56 even one step further. He took two KM56 capsules on top of each other, so one could rotate one by 270° with respect to the other. In M-S stereo one capsule was set to a Figure 8, the other to cardioid and a pattern remote controller enabled one directly to alter the width of the stereo image. This, the SM-2, was Neumann's license in 1956 of a patent by Danish engineer Holger Lauridsen. Neumann, in turn, licensed AKG who, too, took two C-12 microphone capsules and built a stereo C-24.

For ten years the KM50 series microphones were made, but when a newer series of miniature microphones appeared, all but the KM56 were quickly replaced. The KM56 was the only one of the series that allowed changing patterns without changing microphone units. Other problems were to be solved by the new series including a much improved frequency linearity and heftier overload characteristics.

U64, KM63, KM64, KM65, KM66

Sennheiser made their first solid state, RF circuit condenser microphone in 1963. Stefan Kudelski, owner of Nagra, was the developer, and it was Sennheiser's entry into the condenser microphone field. Prior to this, Sennheiser had built only condenser shotgun microphones using their own interference tubes and a special Neumann single nickel membrane pressure transducer, the KM52.

RF was the method used to polarize the Sennheiser capsule and an FM discrimination technique recovered the audio signal. However, the stabilizing of the RF signal source and discrimination circuits was electronically a mean task and Georg Neumann decided to take a stand. He maintained, and as a company philosophy it remains today, that he was not in the electronics business and the key to a quality microphone was in the capsule . . . period.

Neumann's response was the the U64, which used an RCA 7586 NuVistor, and was the first cardioid "linear admittance" microphone, with a virtually flat off-axis frequency response. The new plastic film, Mylar™, developed by DuPont, had many advantages over the original PVC membrane. Mylar™ could be tensioned farther than PVC could and the long term stability of Mylar™ avoided the drying out and stiffening problems which aged PVC exhibited (droop in low frequency response).

The on-axis response of the U64 was virtually flat, bar an intentional 2 dB boost in the mid region to overcome the usual deficiencies of high end room absorption in a distant sound field and a roll-off below 40 Hz to compensate for tight mike proximity effects. The Mylar™ diaphragm was coated with a vacuum deposited gold layer only molecules thick. The acoustical delay network was redesigned and could be made much less expensively. Instead of drilling holes through the backplate, a miller was used to make a number of slits behind the diaphragm which achieved a linear pressure gradient response. Georg Neumann himself developed the cross slit technique and added this patent to his accumulation of nearly 400 already granted.

The U64 fit into the American market fine, but the German broadcasters had their standards, so Neumann had to build the KM63, 64, 65, and 66 which replaced the RCA NuVistor with the Brown Book compatible AC701k preamp.

The 63 was the omni version, the 64 the cardioid, the 65 was a low-cut cardioid, and the 66 had a three pattern switchable head. The KM63, 64, and 65 all had interchangeable capsules, an industry first, so one mike and a few capsules did a lot of jobs. The KM66 repeated the KM56 technique by placing the two KM64 heads back-to-back and the overload problems of the KM60s were helped by a switchable 10 dB capacitative pad placed between the capsule and the preamp input.

The end of the KM60 series mikes manufactured represented the last Klein Mikrofones made with tubes. The "linear admittance" capsule, however, continues in the 70 series and 80 series microphones to this date.

U67, M269, SM69

Neumann's last large diaphragm tube microphone has joined the rare ranks of deified antique equipment even though it is still made in limited quantities today.

Neumann's design aim in producing a new microphone was twofold:

1 - Maintaining low frequency linearity at some distance from the microphone and minimizing the close mike proximity affect without having to change microphones.

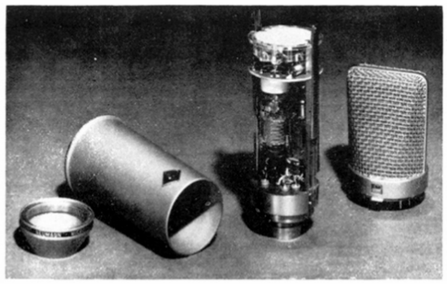
2 - To maintain high frequency linearity in the microphone with distant miking techniques without having to place a high frequency boost in either the capsule or preamp to compensate for transmission losses in the air.

These formidable challenges to Georg Neumann were solved in a brilliantly simple package. The introduction of the U67 in 1960 (originally the U60 but changed for nostalgic reasons with the U47 in mind), generated a microphone capsule design so accomplished that it is still being used in today's solid state equivalents.

The proximity effect problem was solved by Gerhart Bore, Neumann's long-standing physicist in a novel preamplifier design. The proximity effect is a low frequency phenomena affecting directional and pressure gradient microphones beginning at a distance of one wavelength from the microphone. Starting at about 300 Hz, acoustic low frequency boost, due to proximity, of up to 20 dB, can cause the preamp to overload. Conventional attempts at solving this had included a mechanical windscreen and a high pass filter after the mike preamp.

Bore tackled electronically (see patent) the problem of mike amp overload at the low end. He accomplished a low cut filter in a 400 megohm circuit without inductors. The K67 capsule is used as a source for the audio signal as well as an element in the positive feedback chain from the plate through R1 - R3, C1 - C3, and back to the grid. The network is tuned for a low frequency rise as in curve "B" of Bore's patent. Negative feedback through closed S_2, R_x, and C_3 results in curve "A" or a high pass filter. The combination of positive and negative feedback paths results in a sharp 40 Hz cut-off as shown by curve "C." The engaged low end roll-off switch on the U67 results in a curve similar to "C," without the hump, and when disengaged for distant miking gives a response as in curve "D."

The second linearity problem Neumann and Bore conquered was the uni-directional response of high frequency soundwaves at the capsule. The solution was a new capsule design; the K67. Instead of utilizing a single backplate dual membrane capsule, a dual backplate dual membrane combination was realized with a unique acoustic method of membrane isolation above 4 kHz. At those frequencies, the membrane isolation effectively made the microphone a pressure transducer or omni-directional. This resulted in a more naturally linear high end response without additional fudge factors (high frequency boosts) in the capsule or amp. The high end cardioid pattern which is exhibited in actual use, is caused by the mechanically induced acoustical shading of the capsule structure itself.



The U-67 . . . last of the large diaphragm microphones.

This monumental achievement in microphone design has since seen the microphone appreciate from $460.00 in 1967 to a price of over $1,800.00 for the U67s sold today.

The U67 was the second large diaphragm microphone to gain acceptance into the realms of the German broadcast industry. When the German broadcasters' Brown Book had a turn, the U67 EF86 preamp was removed and the perennial AC701k was put in its place. So the M269 was born. The M269 followed early habits and was provided with a remote control aside from the three pattern switch.

Holger Lauridsen's concept from the 1950s of the M/S - X/Y pattern mixing for stereo recording prevailed and the SM69 intensity stereo microphone hailed from Neumann's lab. Two AC701k's, a pair of modified K67s for specialized directional characteristics, and remote controlled pattern switching, made this microphone system compatible with the earlier nickel membraned SM2s.

Georg Neumann continued his already successful microphone career with the 70 and 80 series of microphones. The U87 became as much of a standard in the 1970s as did the 47 and 67 in their days.

Georg Neumann died on August 30, 1976, perhaps the most respected and accomplished man the audio industry has ever known.

Subjectively Speaking

This presentation has attempted to give a brief history of Neumann's tube microphone career, but purposely did not touch on a few areas which would either take the story too far afield, or lead the reader to confuse certain conjecture with fact. There is much mystique to various areas of early tube microphones, but it largely is a matter of opinion as to whether the mystique is valid in our industry. In some cases there may be several variant opinions to the questions raised, so it is left to the reader to make up his own mind.

The original VF-14 version of the U47 has gained absolute notoriety as being the standard of sonic performance for certain instruments or vocals. What is it that differs in their mike from later K47 microphones?

Tony Bongiovi, *Power Station*, New York City: "The U47 is our favorite vocal mike. It has to do with the harmonics and the way they combine with soft music. On loud passages, it overloads some and we prefer the VF-14 to the NuVistor."

Some persons maintain that the key to the sound of the U47 is the fact that the VF-14 tube, would acoustically resonate with a sound source. The tube's shock mounting, they say, is insufficient to compensate for the highly microphonic nature of the tube. This explains to those adherents why the later modifications of the U47 from a VF-14 to the 13CW4 RCA NuVistor hampered the sound quality of the

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AMPLIFYING CIRCUIT FOR CAPACITIVE MICROPHONES

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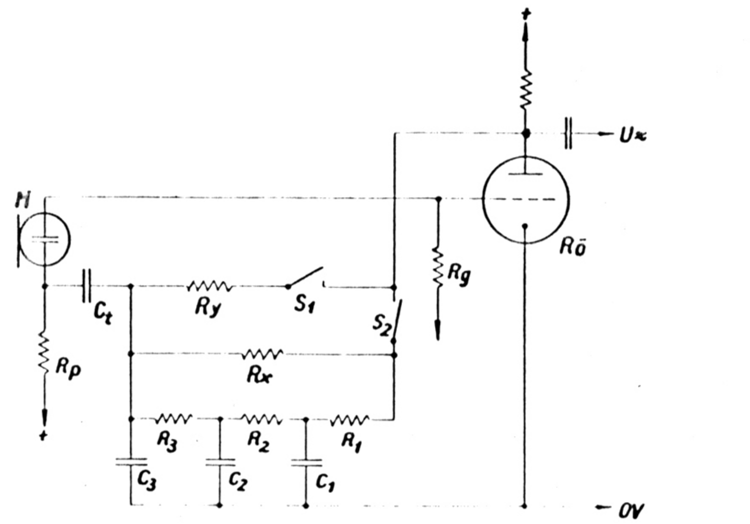


Fig.1

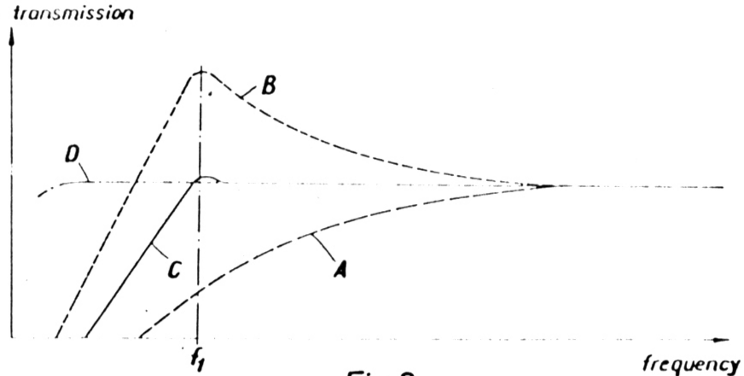
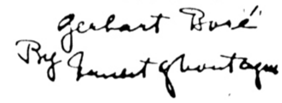
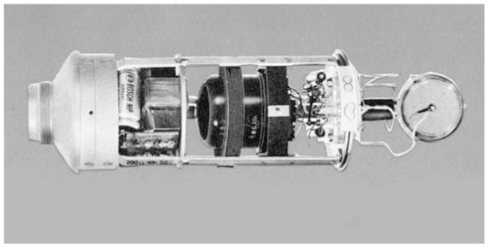


Fig.2

Inventor:





The ubiquitous U-47, showing the VF-14 suspension system used to minimize mechanically generated harmonics.

mike. For the further question of the harmonics generation and subjective evaluation of odd order transistor distortion versus even order tube distortion, it is best to refer to the Journal of the Audio Engineering Society 1973 article by R. Hamm (see reference).

Gotham Audio feels that the mystique of the "Tele" sound may be a multifold phenomena:

1 - That artists, producers, and engineers who made hits in the early 1950s and 1960s feel that they have to use the same mikes to achieve the same repeated success.

2 - A purely sentimental nostalgia for antique equipment which parallels our eye-opening responses to seeing a mint Model A Ford on 5th Avenue today, or

3 - The actual "smooth sound" of the old 47s is caused by a defective capsule.

The early K47s were made by sputtering a thin layer of gold on a poly vinyl chloride (PVC) sheet. The tensioned PVC would eventually begin to dry out and harden, thereby lowering the diaphragm's compliance. The brittle PVC would permit less low frequency excursion and the low frequency drop-off point would rise. The U47s with the hardened PVC are then less susceptible to low frequency proximity effects. If the mike is put in for repair and the diaphragm is in this condition, it is replaced with the new Mylar™ K47 and suddenly the U47 takes on a new character.

How about maintenance on my older tube mikes?

There is very little you can do on a mike yourself, but a lot of preventive care will help.

1 - On the U47/U48 capsules, there is a 0.01 mfd capacitor in parallel with the capsule and its aging will tend to generate noise. It should be replaced with a 0.01 mfd low noise disc capacitor, *very carefully!* Remember, you are in a 400 megohm circuit.

2 - Replacing a defective VF-14 is simple enough if you can get hold of one. However, Gotham indicates that no VF-14 has ever failed! AC701k's are still available, for the time being, and in the U67 either an EF86, 6267, or 6CF8 may be readily had. The U64 uses the 7586 NuVistor.

3 - Power supply maintenance, if ever required, should be self-explanatory. For the older supplies, stabilytes are replace by special PC board circuits.

4 - Moisture can be a problem on condenser capsules. When the humid breath from a singer strikes the capsule, adhering to the membrane and surrounding phenolic tensioning rings, a current leakage path is created which can allow the diaphragm to discharge via the screws in the rings. Later K47s and K67s do not exhibit this problem because the tensioning rings were built differently and there was a more extensive use of insulators. Other than letting the microphone dry out itself (as the U47 virtually does by itself due to the 1780 ohm filament dropping resistor), it is recommended to use a pop screen around the microphone in these applications. Any severe symptoms of either noise or moisture should be referred to Gotham Audio, who is equipped with the specialized tools required for extensive microphone repair.

It has been said that the older mikes often don't require console preamps for adequate level. The average condenser mike level output is about 20 dB above that of a dynamic mike, and due to this the early consoles, with fixed gain preamps, often went into early overload. The only pads that could be used were attenuators before the preamp input transformer. Today's preamps, with true variable gain available, are much less susceptible to overload at high input level. ☐ ☐ ☐

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8 - U.S. Patent No. 3207848. Amplifying Circuit for Capacitive Microphones, G. Boire, 921 1965.


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