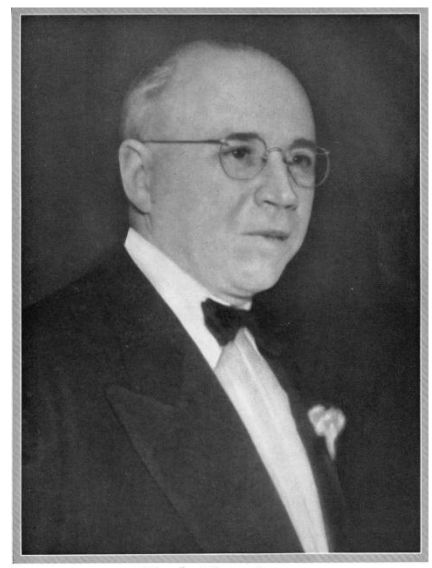
History Of Tedford Crystal Labs Inc.
Cincinnati, Ohio

TEDFORD

CRYSTAL LABS., INC.



R. L. Tedford

Tedford Crystal Labs was founded by Rollo Lesly Tedford (January 20, 1898 – March 28, 1962). "The Name's Tedford; Call Me Ted." Ted was born in Hartshorne, Choctaw Nation, Oklahoma and lived in numerous locations around the USA. Eventually making Cincinnati his home, he graduated from Hughes High School.

His first full-time employment was as a machinist at the Kings Machine Tool Company in Cincinnati. He also did experimental work as a machinist at the Firestone Tire and Rubber Company in Akron, Ohio.

Ted was released from the Navy as a Machinist First Class in 1919. He then started *Ted's Tire and Battery Shop* on Madison Road and in 1921 sold the business and worked several years for an electrical contractor.

Eventually he started an electrical contractor business known as *The Greater Cincinnati Electric Company* in North College Hill. The depression (1929-1939) ended the business.

Rollo L. Tedford was a talented individual with an interest in the field of radio and mechanical design.

We believe he produced the radio to the right, but that is not confirmed. According to the Radio Museum website, the radio was built in 1925 at an address of 35 W. Pearl St. Cincinnati, Ohio.

In 1929 he acquired an Amateur Radio license W8AKW with a 50W authorization according to the 1930 Amateur Radio Callbook.

In 1930 he worked as a radio man for American Airlines at Lunken Field.

An experienced radio engineer, Ted was employed by Crosley Broadcasting Company in Cincinnati (1932-1941). According to Ted's daughter Jan Jennings, he practiced the art of sound effects and was the transcription engineer at WLW Radio. As a master machinist he also fabricated the sound effects used at radio station WLW.

While there, he designed recording equipment using an aluminum disk, before the advent of tape, to record network radio shows for Station WLW.

Most recordings were made in Tedford's home direct from the network. The records were made to be played later when the WLW schedule would not permit direct transmission of the program. In addition, most WLW stars like Red Skelton came to Tedford's home to make personal recordings. Unfortunately, most of the master cuts were melted down during WWII for aluminum.

And, as if that were not enough, he produced equipment which received the first facsimile picture in Cincinnati transmitted from New York. Again, the basement was the scene of this milestone.

Wireless sets were new, and it was difficult to obtain quartz resonators needed for the radios. Undaunted, Tedford decided to try grinding his own. In October 1930, Tedford purchased one pound of Brazilian quartz crystals at $1.00 per pound — quite a contrast to the 1990s price of $75.00/Lb. or 2024 of $200-500/Lb.)

Tedford began making his own radio crystals in his basement as a hobby and advertised in an amateur radio publication, QST, giving other hams an idea of the type of crystal he made. The basement business thrived.

At that time there were so few crystal equipment manufacturers that Tedford had to improvise using common household articles.

One particularly ingenious piece was a saw made from a work bench fitted with a screen door spring which pulled the saw blade through the quartz bar. It took one hour to cut one bar of quartz compared to today's method of cutting 6 bars at once in 4½ hours providing 1800 blanks.

Tedford's lapping machine was another unique design using a converted Delta drill press. It remained in constant use until 1967.

So successful was he in producing finished crystals for his own use that soon other ham operators were requesting "Tedford" crystals for their sets. He began advertising in the amateur radio magazine, QST, and sold them by mail throughout the states.

Just before the start of World War II (1939), Powel Crosley. Jr., owner of WLW and the Crosley corporation which manufactured radios and home appliances, suggest that Tedford leave the company and form his own to make crystals. Crosley agreed to buy the crystals for transmitters that his company was producing under government contract for the U.S. Signal Corps. Encouraged by Crosley's recommendation, Tedford formed the Tedford Crystal Laboratories in March 1942.

The Tedford home on quiet Vernon Ave. in Westwood churned into high production. In 1943, the basement could no longer contain the volume of war crystal business, so the company moved to an old automobile showroom on 3240 Harrison Ave. The first crystals produced at the Harrison Ave. plant went to the Crosley Radio Co. for use in the Army Signal Corps SCR-284 radio set. A total of 150,000 radio sets were produced with 50,000 deployed at the WWII D-Day invasion at Normandy beach.

The employment count steadily grew from 15 to 85 employed at this location. Family members were still counted among the employees, although Tedford's sons had enlisted in the service at the start of the war. The older one enlisted in the U.S. Signal Corps where he worked on equipment containing Tedford crystals!

Then it was 1945 and the good news of peace translated into the bad news of canceled orders. Government contracts terminated instantly and so did production at the 3240

Harrison. Tedford sold off some of his equipment and stored the rest in a rented garage on North Bend Rd.

The following year, wishing to keep the company alive, he resumed production in a rented store front at 1625 Chase Street in Northside. In 1949 the company moved to a two-story building at 4126 Colerain Ave.

Beginning in 1945 the Voice of America transmitting plant in West Chester, Ohio began to purchase all their crystals from Tedford Crystal Labs Inc.

Rolo Tedford retrenched and began experiments to develop improved crystal units using hermetically sealed holders and plated electrodes as well as equipment for volume production. He began to consider rebuilding his business with the commercial market in mind.

Both sons, Bud and Bob, discharged from the military and now in college, joined him in his research. By 1947, Bud Tedford had graduated from the University of Cincinnati and agreed to join the business with his father with the stipulation that they go after the big customers. One of the largest crystal users at that time was Motorola in Chicago which was just beginning to manufacture their own crystals. Through a stroke of luck or fate the gentleman in charge of the new crystal operation turned out to be an old friend of senior Tedford. TCL wooed Motorola and in turn received a royal welcome and a big order. Thus started a love affair between the electronics giant, Motorola and small Tedford Crystal Labs that would continue for many years.

Then in 1956, tragedy struck when Bud Tedford was killed in a plane crash. The older son, R. H. (Bob) Tedford, not in the family business at the time joined the company to help maintain production.

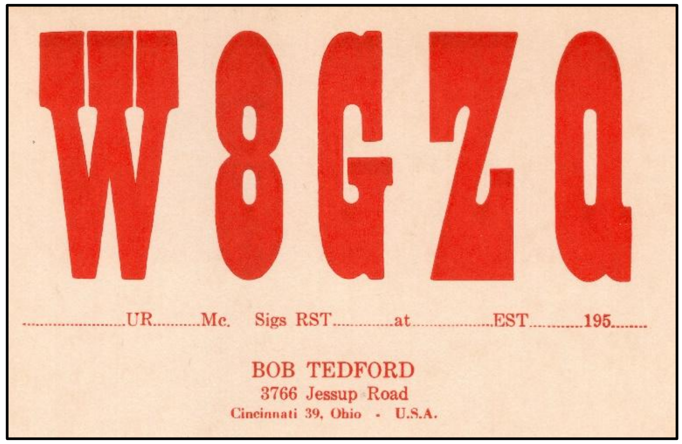
Large orders continued to flow in from Motorola and in June 1959, plant two was added at the 1661 blue rock St., a few blocks from plant one on Colerain. Twenty employees worked in plant two which housed the saw department and the rough lapping process. Plant one employed 60 production workers and housed finished lapping and crystal finishing. Bob Tedford was now overseeing most of the production and sales effort.

Prior to Rollo passing away he sold 50% of the business to Harry S. Gantz, a resident of Cincinnati.

In March 1962, R. L. (Rollo) Tedford suffered a fatal heart attack, ending an entrepreneurship sparked by a fascination with electronics and a spirit of invention.

Upon Rollo's death his 50% of the company was divided between his son Robert Harry Tedford 25% and his wife Mary, 25%.

Harry S. Gantz and his son David A. Gantz continued to own the other 50% of the company.



Bob Tedford, also an amateur radio operator, became president of Tedford Crystal Labs and, despite the loss of its founder the business continued to prosper. In 1965, the company added its third location at 4515 Kirby Rd. Tedford Labs now employed 180 people, ran three shifts and owned a company car to shuttle people, paper and equipment among the three plants.

Ninety percent of Tedford's business was with Motorola who needed crystals for their commercial two-way radio communications equipment. As Bob Tedford says, "we really had the tiger by the tail in those days. We didn't need salespeople – we had almost too much business!" Every day three or four orders would come in over the teletype machine in the office. Most of these orders specified a week turnaround and Tedford labs became known for their rapid delivery and exceptional reliability. Quite a few orders were even taken for next day delivery and Bob Tedford would personally drive to the airport at midnight to ensure that the crystals went out Emery Air Freight. As Bob Tedford remembers, "the key to the company's success was that it would do somersaults for delivery."

And somersaults were necessary to beat the ever-growing crystal competitors such as James Knight (now CTS Knights), McCoy, Bliley, Reeves Hoffman and P.R. Hoffman.

Tedford Labs crystal business continued to prosper under continuous upgrading of crystal specifications and requirements for more sophisticated tolerances, mounting, plating and packaging. In 1964 Motorola asked Tedford Labs to consider starting a filter line which they did that same year. The line employed seven direct laborers and one filter engineer. Other customers were added to Motorola, but the filter business was never a significant contributor to the bottom line and lasted only six or seven years.

In 1967, Tedford Crystal Labs took a major step forward by purchasing the present-day site on Gray Rd. and building a 17,000 square foot facility which consolidated the three different locations. Tedford and his employees were rightfully proud of their new air-conditioned plant.

Groundbreaking for the Gray Road facility.

L-R William Breiner, Robert H Tedford, George (Mickey) Gump, Sam Miller, Bortolo M. Pradal, Johnny Weiss, Jerry Schumaker

Tedford Crystal Labs Inc., 4814 Gray Road, Cincinnati, Ohio (1990s).

Expanded Tedford Crystal Labs building today, 2024.

By 1967 Robert Tedford was experiencing owner conflicts and consequently wanted to sell the company.

Harry S. Gantz and his son David A. Gantz sold their half of TCL to an out-of-town silent partner (R. L. Drake).

In 1967, RF Communications (RFC) in Rochester NY was in the market to purchase a crystal source to supply their product line. Bob Drake already had a relationship with RF Communications and knew about their desire to acquire a crystal manufacturer.

Consequently, in 1967 Bob Drake sold his half of TCL to RFC and at the same time arranged the sale of Tedford's half of TCL to RF Communications. Robert Tedford remained president until July.

In 1969 RF Communications was acquired by Harris Corp.

The Gray Rd. firm changed names three times that year from Tedford Crystal Labs to RF Communications to RF Harris when RF Communications merged with Harris. The years between 1969 and 1973 saw a steady rotation of general and production managers sent from Harris headquarters in Rochester, NY to manage the Gray Rd. facility.

The crystal business was categorized by Harris as a break-even entity controlling 20% of the market for the high technology crystals used in two-way radios for police & fire departments, the military and corporations. It was not until 1973 when Kirk Dance was sent from Harris that the plant gained management continuity.

Under Dance's seven-year reign from 1973 to 1980 the plant's annual revenues increased from $1 million to $4.5 million and four new product lines were established, one of them being oscillators. Then in 1980, after a six-month fight for financing Dance and his management team purchased the plant from Harris for essentially book value, $2.3 million and the name was changed to CINOX, an abbreviation of Cincinnati Oscillators and Crystals.

Dance liked to characterize himself as a "swinger" and the refinement of the northeastern Harris managers soon faded into the wake of Dance's colorful, aggressive management style. Under his leadership oscillators grew as a significant business element and an 8000 square foot addition was built for that line in 1983.

In 1984 Dance realized his entrepreneurial goal by selling CINOX to EG&G Inc. of Wellesley, Massachusetts. The employees of CINOX will long remember the sale with a touch of bitterness, reading of the finalized transaction in the newspaper rather than hearing the news from Dance firsthand.

EG&G Inc. was originally founded as Edgerton, Germeshausen and Grier, Inc. and the entire company was housed in a converted garage in Boston, MA. By 1985, EG&G was a widely diversified technology-oriented corporation composed of 150 highly specialized business elements with 23,000 employees. At that time a strategy for corporate growth centered on the acquisition of small profitable businesses in related high-tech fields. CINOX, acquired in 1984, had already been grouped with Rubidium, another small, high tech product line in Salem, MA to form the Frequency Products Division. In 1985 a Kansas crystal company Cirtech, was purchased and added to the frequency products division.

A significant milestone for the division came in November 1987 with the relocation of Cirtech to Cincinnati. A 20,000 square foot addition was completed in July 1988 to accommodate the filter and module lines and the 14 employees relocating from Kansas. In 1989 Rubidium Products was transferred from the Frequency Products Division to the Defense Systems Group and that same year the merger of CINOX and Cirtech was completed under the new name of EG&G Frequency Products Inc.

EG&G Frequency Products continues the culture begun by R. L. Tedford, of continuously improving products, process, and organization to expect and achieve nothing less than excellence.

In 2024, over 3.5 billion crystal oscillators are made relying on synthetic crystal manufacturing.

Synthetic crystals were first made in Italy in 1905. In Japan, synthetic crystals were successfully grown in a small autoclave (a high-temperature, high-pressure furnace) at Yamanashi University in 1954.

Modern crystal growing takes from two to six months in an autoclave with a temperature of 680°F and pressurized between 16,000 – 24,000 psi.

Leland L. Hite
National VOA Museum of Broadcasting
November 25, 2024

Sources:

Rollo Lesly Tedford's grandson, William Leslie Tedford, MD, pictured right, provided archived documents from TCL and greatly assisted with editing and overall guidance. Thank you!

History of Southwestern Ohio, The Miami Valleys, Volume 3, Pages 344-345, 1964

Brief Life History for Rollo L Tedford

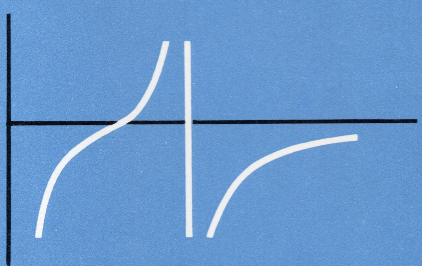
A History Of EG&G Frequency Products, Inc. October 13, 1991

A History of the Quartz Crystal Industry in the USA

Obituary for Robert H. Tedford

Obituary Robert H Tedford #2

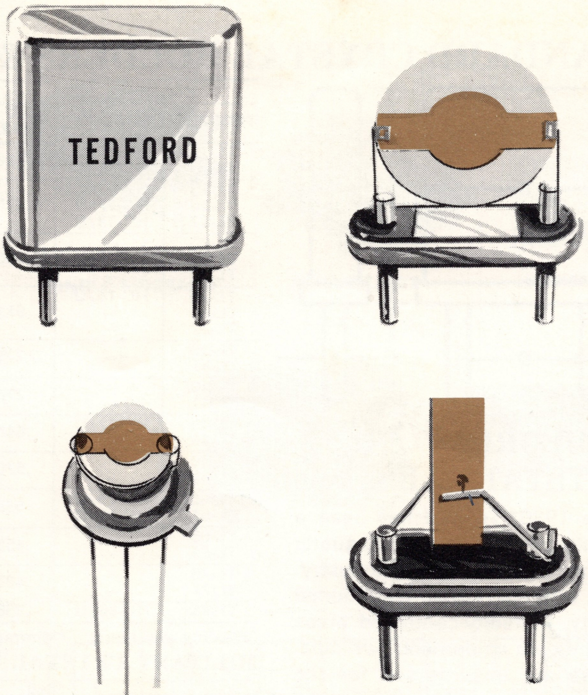
Epson High-Quality Synthetic Crystals



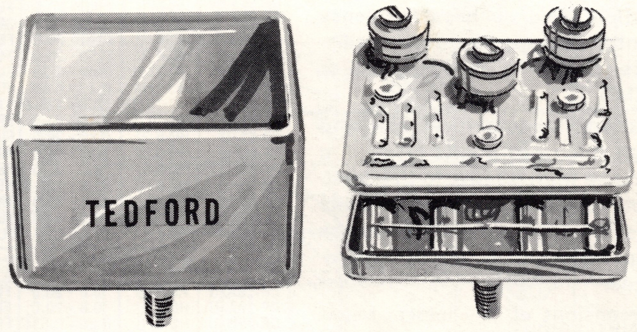
HIGH QUALITY
QUARTZ CRYSTALS
FOR PRECISION
FREQUENCY CONTROL

TEDFORD CRYSTAL LABS., INC.

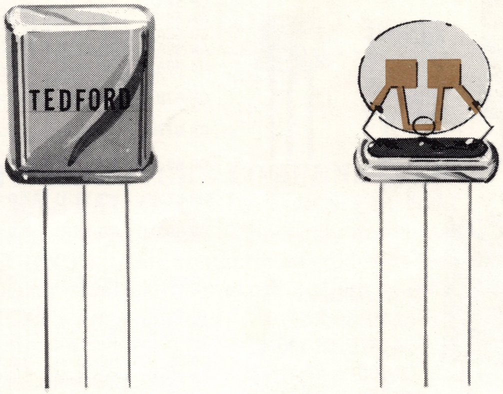
PRECISION FREQUENCY CONTROL DEVICES



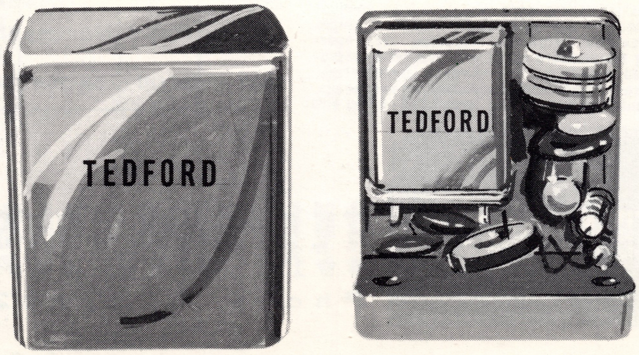
QUARTZ CRYSTALS



DISCRETE CRYSTAL FILTERS

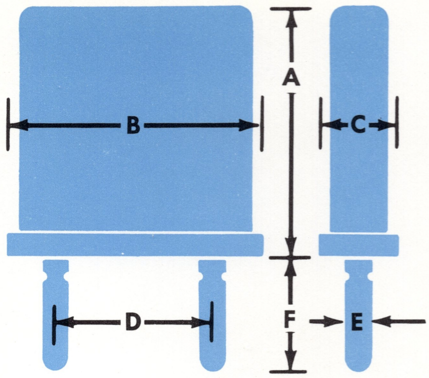


MONOLITHIC CRYSTAL FILTERS



TEMPERATURE COMPENSATED CRYSTAL OSCILLATORS (TCXO)

TEDFORD
CRYSTAL LABS., INC.



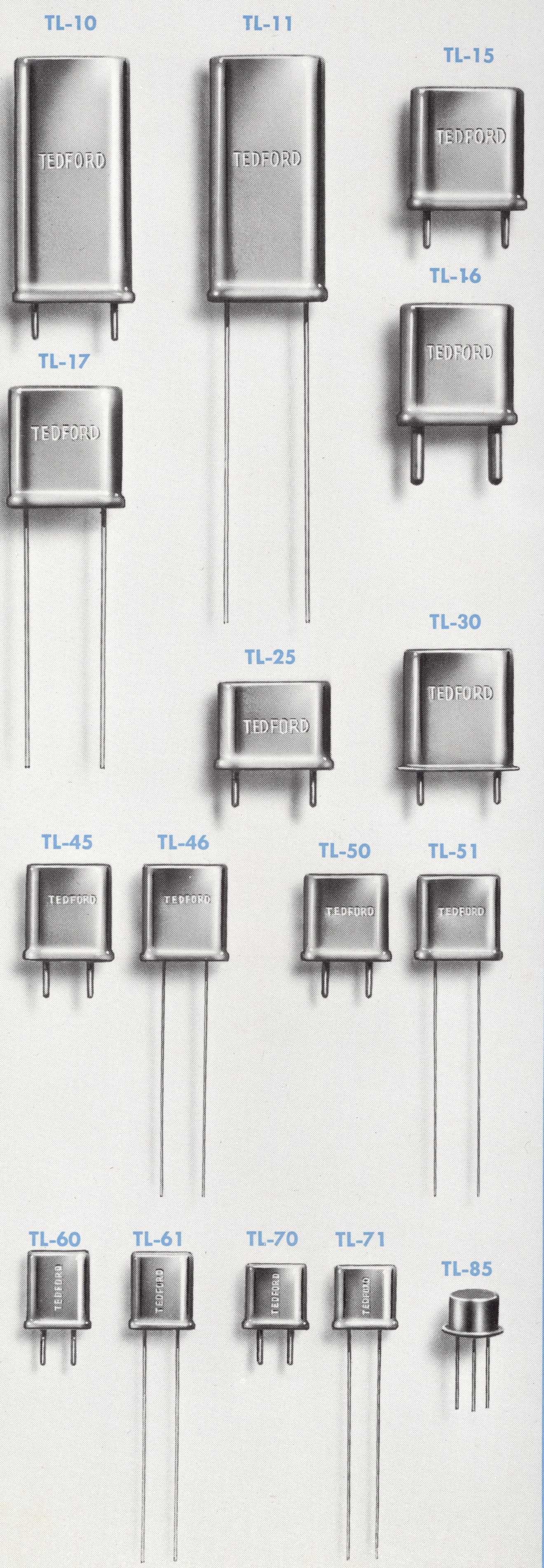
STANDARD CRYSTAL HOLDERS & AVAILABLE FREQUENCY RANGES

Tedford manufactures low and high frequency quartz crystals in a range from 90 kHz to 210 MHz. Both standard and custom units in small or large quantities can be supplied for a variety of applications.

HOLDER			CASE DIMENSIONS* TERMINATIONS						FREQUENCY RANGE
TEDFORD	ACTUAL SIZE	MILITARY	A (MAX.)	B (MAX.)	C (MAX.)	D (±.008)	E (±.002)	F (MAX.)	(MHz)
TL-10 TL-11		HC-13/U HC-34/U	1.526	.757	.352	.486	.050 .030[1]	.248 1.500[2]	0.09—0.25
TL-15 TL-16 TL-17		HC-6/U HC-17/U HC-33/U	.775	.757	.352	.486	.050 .093 .030[1]	.248 .447 1.500[2]	0.20—210.0
TL-20 TL-21 TL-22		— — —	.690	.757	.352	.486	.050 .093 .030[1]	.248 .447 1.500[2]	0.20—0.80 and 2.0—210.0
TL-25 TL-26 TL-27		HC-14/U — —	.583	.757	.352	.486	.050 .093 .030[1]	.248 .447 1.500[2]	0.20—0.80 and 2.0—210.0
TL-30 TL-31	Cold-Weld	—	.775	.757	.352	.486	.050 .030[1]	.248 1.500[2]	0.20—210.0
TL-40 TL-41	Slim Line	— —	.775	.757	.240	.486	.050 .030[1]	.248 1.500[2]	0.20—210.0
TL-45 TL-46		HC-32/U —	.640	.567	.237	.275	.040 .017[1]	.248 1.500[2]	1.50—210.0
TL-50 TL-51		— —	.570	.567	.237	.275	.040 .017[1]	.248 1.500[2]	1.50—210.0
TL-60 TL-61		HC-25/U HC-18/U	.530	.435	.183	.192	.040 .017[1]	.248 1.500[2]	2.90—210.0
TL-65 TL-66		— —	.450	.435	.183	.192	.040 .017[1]	.248 1.500[2]	2.90—210.0
TL-70 TL-71		— —	.425	.435	.183	.192	.040 .017[1]	.248 1.500[2]	5.0—210.0
TL-85		HC-35/U	.250	.390 Dia.		.200	.0185[1]	.600	5.0—210.0

[1]Flexible wire leads.
[2]Minimum length.
*Dimensions shown in inches.

Dimensions of the holders below and the frequency ranges they can accommodate are indicated in the table to the left.



MILITARY CRYSTAL TYPES—CONTR

MIL. TYPE	HOLDER	FREQ. RANGE (MHz)	MODE	RESONANCE	C
CR-26A/U	HC-6/U	0.20 - 0.555	FUND.	SERIES	
CR-27A/U	HC-6/U	0.80 - 20.0	FUND.	PARALLEL	
CR-28A/U	HC-6/U	0.80 - 20.0	FUND.	SERIES	
CR-32A/U	HC-6/U	10.0 - 75.0	3RD, 5TH	SERIES	
CR-35A/U	HC-6/U	0.80 - 20.0	FUND.	SERIES	
CR-36A/U	HC-6/U	0.80 - 20.0	FUND.	PARALLEL	
CR-42A/U	HC-13/U	0.09 - 0.25	FUND.	PARALLEL	
CR-47A/U	HC-6/U	0.19 - 0.50	FUND.	PARALLEL	
CR-59A/U	HC-18/U	50.0 - 125.0	5TH	SERIES	
CR-61/U	HC-18/U	17.0 - 61.0	3RD	SERIES	
CR-62/U	HC-6/U	0.80 - 20.0	FUND.	PARALLEL	
CR-65/U	HC-6/U	10.0 - 61.0	3RD	SERIES	
CR-68/U	HC-6/U	3.0 - 20.0	FUND.	PARALLEL	
CR-75/U	HC-6/U	50.0 - 125.0	5TH	SERIES	
CR-84/U	HC-25/U	17.0 - 61.0	3RD	SERIES	
CR-104/U	HC-33/U	0.2 - 0.58	FUND.	PARALLEL	
CR-109/U	HC-25/U	10.0 - 11.5	FUND.	PARALLEL	

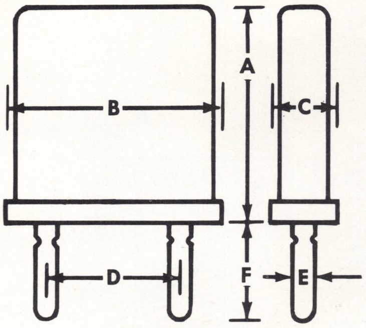
MILITARY CRYSTAL TYPES—NON CONT

MIL. TYPE	HOLDER	FREQ. RANGE (MHz)	MODE	RESONANCE
CR-18A/U	HC-6/U	0.8 - 20.0	FUND.	PARALLEL
CR-19A/U	HC-6/U	0.8 - 20.0	FUND.	SERIES
CR-25B/U	HC-6/U	0.20 - 0.555	FUND.	SERIES
CR-33A/U[3]	HC-6/U	10.0 - 25.0	3RD	PARALLEL
CR-37A/U	HC-13/U	0.09 - 0.25	FUND.	PARALLEL
CR-45/U	HC-6/U	0.455	FUND.	SERIES
CR-46A/U[3]	HC-6/U	0.20 - 0.50	FUND.	PARALLEL
CR-52A/U	HC-6/U	10.0 - 61.0	3RD	SERIES
CR-54A/U	HC-6/U	50.0 - 125.0	5TH	SERIES
CR-55/U	HC-18/U	17.0 - 61.0	3RD	SERIES
CR-56A/U	HC-18/U	50.0 - 125.0	5TH	SERIES
CR-58A/U	HC-17/U	0.8 - 20.0	FUND.	PARALLEL
CR-60A/U	HC-18/U	5.0 - 20.0	FUND.	SERIES
CR-63B/U	HC-6/U	0.20 - 0.555	FUND.	PARALLEL
CR-64/U	HC-18/U	2.9 - 20.0	FUND.	PARALLEL
CR-66/U	HC-6/U	3.0 - 20.0	FUND.	PARALLEL
CR-67/U	HC-18/U	17.0 - 61.0	3RD	SERIES
CR-69A/U	HC-18/U	2.9 - 25.0	FUND.	PARALLEL
CR-76/U	HC-18/U	17.0 - 61.0	3RD	SERIES
CR-77/U	HC-25/U	17.0 - 62.0	3RD	SERIES
CR-78/U	HC-25/U	3.0 - 20.0	FUND.	PARALLEL
CR-79/U	HC-25/U	5.0 - 20.0	FUND.	SERIES
CR-80/U	HC-18/U	50.0 - 125.0	5TH	SERIES
CR-81/U	HC-25/U	17.0 - 61.0	3RD	SERIES
CR-82/U	HC-25/U	50.0 - 125.0	5TH	SERIES
CR-83/U	HC-25/U	50.0 - 125.0	5TH	SERIES
CR-85/U	HC-6/U	0.8 - 20.0	FUND.	SERIES
CR-89/U	HC-32/U	2.12 - 6.20	FUND.	PARALLEL
CR-97/U[3]	HC-18/U	8.0 - 10.0	FUND.	PARALLEL
CR-98/U	HC-25/U	50.0 - 134.0	5TH	SERIES
CR-100/U	HC-6/U	1.75 - 3.50	FUND.	PARALLEL
CR-105/U	HC-18/U	48.0 - 70.0	5TH	SERIES
CR-106/U	HC-18/U	10.5 - 11.5	FUND.	PARALLEL
CR-107/U	HC-18/U	70.0 - 125.0	5TH	SERIES
CR-110/U	HC-18/U	63.0 - 75.0	5TH	SERIES
CR-111/U	HC-18/U	17.0 - 27.0	3RD	SERIES
CR-114/U	HC-25/U[4]	2.90 - 3.85	FUND.	PARALLEL

[1] Maximum frequency deviation from nominal frequency over operating temperature range.

[2] Maximum frequency deviation over operating temperature range with respect to measured frequency at reference temperature.

STANDARD CRYSTAL HOLDERS & AVAILABLE FREQUENCY RANGES



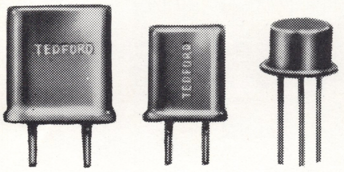
TEDFORD CRYSTAL LABS., Inc.

Since 1930, Tedford has been a steadily growing supplier of quartz crystals to the electronic industry. Now, with our new air conditioned facility, humidity-controlled areas and modern equipment, our capabilities are unsurpassed for the design and manufacture of high-reliability crystals for commercial and military applications.

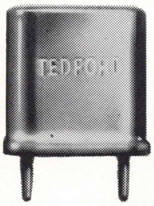
Tedford also supplies frequency control devices, filters and oscillators, shown in section 2700 of EEM.

Tedford manufactures low and high frequency quartz crystals in a range from 90 KHz to 210 MHz. Both standard and custom units in small or large quantities can be supplied for a variety of applications.

Dimensions of the holders below and the frequency ranges they can accommodate are indicated in the table to the right.



TL-45 TL-60 TL-85



TL-15

Also available:
CR-89/U, CR-97/U, CR-98/U, CR-100/U, CR-105/U, CR-106/U, CR-107/U, CR-110/U, CR-111/U, CR-114/U

HOLDER		CASE DIMENSIONS* TERMINATIONS						FREQUENCY RANGE (MHz)
TEDFORD	MILITARY	A (MAX.)	B (MAX.)	C (MAX.)	D (±.008)	E (±.002)	F (MAX.)	
TL-10 TL-11	HC-13/U HC-34/U	1.526	.757	.352	.486	.050 .030[1]	.248 1.500[2]	0.09—0.25
TL-15 TL-16 TL-17	HC-6/U HC-17/U HC-33/U	.775	.757	.352	.486	.050 .093 .030[1]	.248 .447 1.500[2]	0.20—210.0
TL-20 TL-21 TL-22	— — —	.690	.757	.352	.486	.050 .093 .030[1]	.248 .447 1.500[2]	0.20—0.80 and 2.0—210.0
TL-25 TL-26 TL-27	HC-14/U — —	.583	.757	.352	.486	.050 .093 .030[1]	.248 .447 1.500[2]	0.20—0.80 and 2.0—210.0
TL-30 TL-31	—	.775	.757	.352	.486	.050 .030[1]	.248 1.500[2]	0.20—210.0
TL-40 TL-41	— —	.775	.757	.240	.486	.050 .030[1]	.248 1.500[2]	0.20—210.0
TL-45 TL-46	HC-32/U —	.640	.567	.237	.275	.040 017[1]	.248 1.500[2]	1.50—210.0
TL-50 TL-51	— —	.570	.567	.237	.275	.040 .017[1]	.248 1.500[2]	1.50—210.0
TL-60 TL-61	HC-25/U HC-18/U	.530	.435	.183	.192	.040 .017[1]	.248 1.500[2]	2.90—210.0
TL-65 TL-66	— —	.450	.435	.183	.192	.040 .017[1]	.248 1.500[2]	2.90—210.0
TL-70 TL-71	— —	.425	.435	.183	.192	.040 .017[1]	.248 1.500[2]	5.0—210.0
TL-85	HC-35/U	.250	.390 Dia.		.200	.0185[1]	.600	5.0—210.0

[1]Flexible wire leads. [2]Minimum length. *Dimensions shown in inches.

MILITARY CRYSTAL TYPES—CONTROLLED TEMPERATURE CONDITIONS

MIL. TYPE	HOLDER	FREQ. RANGE (MHz)	MODE	RESONANCE	CAPACITANCE LOAD (pf)	REF. TEMP. °C	FREQ. TOL.[1] PERCENT (±)	OPR. RANGE °C	STABILITY[2] PERCENT (±)
CR-26A/U	HC-6/U	0.20 - 0.555	FUND.	SERIES	—	75±1	0.002	70 TO 80	0.0005
CR-27A/U	HC-6/U	0.80 - 20.0	FUND.	PARALLEL	32.0±0.5	75±1	0.002	70 TO 80	0.0005
CR-28A/U	HC-6/U	0.80 - 20.0	FUND.	SERIES	—	75±1	0.002	70 TO 80	0.0005
CR-32A/U	HC-6/U	10.0 - 75.0	3RD, 5TH	SERIES	—	75±1	0.002	70 TO 80	0.0005
CR-35A/U	HC-6/U	0.80 - 20.0	FUND.	SERIES	—	85±1	0.002	80 TO 90	0.0005
CR-36A/U	HC-6/U	0.80 - 20.0	FUND.	PARALLEL	32.0±0.5	85±1	0.002	80 TO 90	0.0005
CR-42A/U	HC-13/U	0.09 - 0.25	FUND.	PARALLEL	32.0±0.5	75±1	0.003	70 TO 80	0.002
CR-47A/U	HC-6/U	0.19 - 0.50	FUND.	PARALLEL	20.0±0.5	75±1	0.002	70 TO 80	0.0005
CR-59A/U	HC-18/U	50.0 - 125.0	5TH	SERIES	—	85±1	0.002	80 TO 90	0.0005
CR-61/U	HC-18/U	17.0 - 61.0	3RD	SERIES	—	85±1	0.002	80 TO 90	0.0005
CR-62/U	HC-6/U	0.80 - 20.0	FUND.	PARALLEL	32.0±0.2	75±1	0.001	70 TO 80	0.0005
CR-65/U	HC-6/U	10.0 - 61.0	3RD	SERIES	—	75±1	0.001	70 TO 80	0.00025
CR-68/U	HC-6/U	3.0 - 20.0	FUND.	PARALLEL	32.0±0.5	75±1	0.002	70 TO 80	0.0005
CR-75/U	HC-6/U	50.0 - 125.0	5TH	SERIES	—	75±1	0.001	70 TO 80	0.00025
CR-84/U	HC-25/U	17.0 - 61.0	3RD	SERIES		85±1	0.002	80 TO 90	0.0005
CR-104/U	HC-33/U	0.2 - 0.58	FUND.	PARALLEL	21.5±0.5	75±1	0.002[5]	70 TO 80	0.0005
CR-109/U	HC-25/U	10.0 - 11.5	FUND.	PARALLEL	32.0±0.5	85±2	0.002	80 TO 90	0.0005

MILITARY CRYSTAL TYPES—NON CONTROLLED TEMPERATURE CONDITIONS

MIL. TYPE	HOLDER	FREQ. RANGE (MHz)	MODE	RESONANCE	CAPACITANCE LOAD (pf)	REF. TEMP. °C	FREQ. TOL. PERCENT (±)	OPR. RANGE °C	STABILITY PERCENT (±)
CR-18A/U	HC-6/U	0.8 - 20.0	FUND.	PARALLEL	32.0±0.5		0.005	—55 TO +105	
CR-19A/U	HC-6/U	0.8 - 20.0	FUND.	SERIES	—		0.005	—55 TO +105	
CR-25B/U	HC-6/U	0.20 - 0.555	FUND.	SERIES	—		0.010	—40 TO +85	
CR-33A/U[3]	HC-6/U	10.0 - 25.0	3RD	PARALLEL	32.0±0.5		0.005	—55 TO +105	
CR-37A/U	HC-13/U	0.09 - 0.25	FUND.	PARALLEL	20.0±0.5		0.020	—40 TO +70	
CR-45/U	HC-6/U	0.455	FUND.	SERIES	—		0.020	—40 TO +70	
CR-46A/U[3]	HC-6/U	0.20 - 0.50	FUND.	PARALLEL	20.0±0.5		0.010	—40 TO +85	
CR-52A/U	HC-6/U	10.0 - 61.0	3RD	SERIES	—		0.005	—55 TO +105	
CR-54A/U	HC-6/U	50.0 - 125.0	5TH	SERIES	—		0.005	—55 TO +105	
CR-55/U	HC-18/U	17.0 - 61.0	3RD	SERIES	—		0.005	—55 TO +105	
CR-56A/U	HC-18/U	50.0 - 125.0	5TH	SERIES	—		0.005	—55 TO +105	
CR-58A/U	HC-17/U	0.8 - 20.0	FUND.	PARALLEL	32.0±0.5		0.005	—55 TO +105	
CR-60A/U	HC-18/U	5.0 - 20.0	FUND.	SERIES	—		0.005	—55 TO +105	
CR-63B/U	HC-6/U	0.20 - 0.555	FUND.	PARALLEL	20.0±0.5		0.010 0.015	—40 TO +70 { —55 TO —40 { +70 TO +90	
CR-64/U	HC-18/U	2.9 - 20.0	FUND.	PARALLEL	30.0±0.5		0.005	—55 TO +105	
CR-66/U	HC-6/U	3.0 - 20.0	FUND.	PARALLEL	30.0±0.5		0.002 0.003	—40 TO +90 { —55 TO —40 { +90 TO +105	
CR-67/U	HC-18/U	17.0 - 61.0	3RD	SERIES	—		0.0025	—55 TO +105	
CR-69A/U	HC-18/U	2.9 - 25.0	FUND.	PARALLEL	30.0±0.5		0.002 0.003	—40 TO +90 { —55 TO —40 { +90 TO +105	
CR-76/U	HC-18/U	17.0 - 61.0	3RD	SERIES	—		0.002 0.003	—40 TO +90 { —55 TO —40 { +90 TO +105	
CR-77/U	HC-25/U	17.0 - 62.0	3RD	SERIES	—		0.002 0.003	—40 TO +90 { —55 TO —40 { +90 TO +105	
CR-78/U	HC-25/U	3.0 - 20.0	FUND.	PARALLEL	30.0±0.5		0.005	—55 TO +105	
CR-79/U	HC-25/U	5.0 - 20.0	FUND.	SERIES	—		0.005	—55 TO +105	
CR-80/U	HC-18/U	50.0 - 125.0	5TH	SERIES	—		0.002 0.003	—40 TO +90 { —55 TO —40 { +90 TO +105	
CR-81/U	HC-25/U	17.0 - 61.0	3RD	SERIES	—		0.005	—55 TO +105	
CR-82/U	HC-25/U	50.0 - 125.0	5TH	SERIES	—		0.005	—55 TO +105	
CR-83/U	HC-25/U	50.0 - 125.0	5TH	SERIES	—		0.002 0.003	—40 TO +90 { —55 TO —40 { +90 TO +105	
CR-85/U	HC-6/U	0.8 - 20.0	FUND.	SERIES	—		0.002 0.003	—40 TO +90 { —55 TO —40 { +90 TO +105	

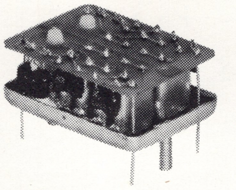
[1]Maximum frequency deviation from nominal frequency over operating temperature range. [2]Maximum frequency deviation over operating temperature range with respect to measured frequency at reference temperature. [3]Requires government approval on new equipment design. [5]±.001% from 0.485—0.580 MHz.

TEDFORD CRYSTAL LABS, INC.
FREQUENCY CONTROL DEVICES

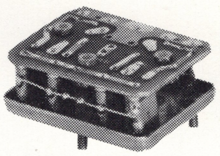
TEDFORD CRYSTAL LABORATORIES, INC.
4914 Gray Road, Cincinnati, Ohio 45232
Phone 513/542-5555

FREQUENCY CONTROL DEVICES

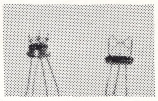
Besides manufacturing precision quartz crystals, shown in Section 2300 of EEM, Tedford Crystal Labs. is rapidly becoming a leader in the field of crystal filters and oscillators. Our present capability includes bandpass, band-reject and single sideband crystal filters in either monolithic or discrete configurations. Tedford Labs. also offers a complete line of temperature compensated crystal oscillators.



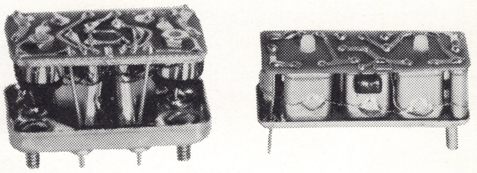
SINGLE SIDEBAND



BAND-REJECT



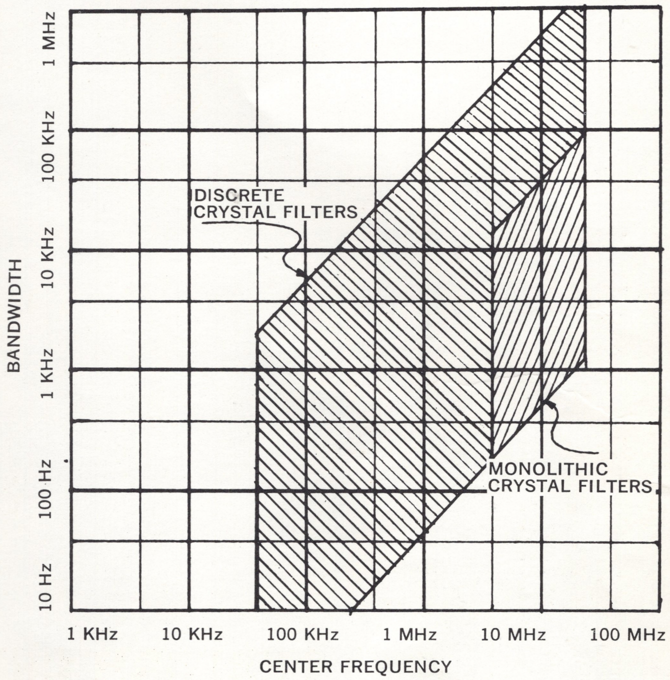
MONOLITHIC



BANDPASS

CRYSTAL FILTERS

Crystal filters have found a wide range of uses in the communications field and Tedford Crystal Labs. stands ready to assist the design engineer in specifying his particular filter. By using the latest techniques employing multi-electrode crystals or monolithic crystal filters, Tedford Labs is able to offer a compact design at a minimum cost. As an aid in the first phase of design, consult the chart at the right to determine the feasible relationship between frequency and bandwidth. A step-by-step procedure for specifying crystal filters is available, upon request, from Tedford Crystal Labs.



DISCRETE CRYSTAL FILTERS

Off-the-shelf types are listed, custom designed types available upon request.

Center freq.	BW 3db	BW 60db	Type
21.900 MHz	2.000 KHz	15.000 KHz	Band Pass
14.200 MHz	5.000 KHz	27.000 KHz	Band Pass
10.700 MHz	240.0 KHz	1100.0 KHz	Band Pass
9.000 MHz	2.000 KHz	3.800 KHz	Single Sideband Pair
646.00 KHz	200 Hz	7.000 KHz	Band Pass
455.00 KHz	500 Hz	3.500 KHz	Band Pass

MONOLITHIC CRYSTAL FILTERS

Our capabilities include a line of monolithic crystal filters in the frequency range of 5 to 30 MHz. Custom engineered two pole filters are now available with either CHEBISHEV or BUTTERWORTH transmission characteristics. Filters with 3db bandwidths from 0.005 to 0.25%, insertion loss of 0.5 to 2db, and 3db to 30db ratio of 1:5 are now available.

CENTER FREQ.	BW 3db	BW 30db	INSERTION LOSS	RATIO
10.700 MHz	23.000 KHz min.	92.000 KHz max.	1db max.	1:4
11.700 MHz	23.000 KHz min.	92.000 KHz max.	1db max.	1:4
11.700 MHz	15.000 KHz min.	60.000 KHz max.	1db max.	1:4
21.900 MHz	7.000 KHz min.	35.000 KHz max.	1db max.	1:5
21.900 MHz	15.000 KHz min.	60.000 KHz max.	.7db max.	1:4
21.900 MHz	5.000 KHz min.	25.000 KHz max.	1db max.	1:5
21.400 MHz	15.000 KHz min.	60.000 KHz max.	.7db max.	1.4
20.000 MHz	14.000 KHz min.	58.000 KHz max.	.7db max.	1:4

NOTE: Input and output impedance are dependent upon ripple, frequency range and transmission characteristics. Typically they range between 100 ohms and 5K ohms with ripple between 0 and 1db. Temperature drift tolerances of ±0.005% in the temperature range of —40 to +70°C are possible.

CUSTOM DESIGNS AVAILABLE

Why not give us a shot at your next spec on crystals, crystal filters, integrated filters or temperature compensated crystal oscillators (TCXO)? Maybe we can cut your costs, and give you a better product in the bargain. Write for free product catalogs.

TEMPERATURE COMPENSATED CRYSTAL OSCILLATORS (TCXO)

Tedford Crystal Labs. is presently developing a complete line of TCXO's. Using computer-aided design techniques your particular needs can be met with optimum cost and quick delivery. TCXO's are available in the frequency range of 5 to 18 MHz, with the following tolerances.

Standard Stability	±5ppm	—30 to +70°C
Custom Design Stability	±1ppm	—30 to +70°C
Custom Design Stability	±0.5ppm	—10 to +50°C

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Please do not hesitate to call or write.
We are always happy to offer assistance
and discuss special applications.

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