Conexões Infravermelhas

Paleotermografia, as origens dos equipamentos termográficos

Por Eng. Attílio Bruno Veratti   Nível III ITC e ABENDI

Nesse artigo de Conexões revemos o primeiro equipamento infravermelho lançado no mercado há mais de 47 anos e voltamos cerca de 65 anos em busca do elo perdido.

Parte I

Em 1964 a AGA Infrared Systems da Suécia lançava sua primeira série de termovisores destinados ao uso civil, era a linha Thermovision 600 (imagem 01).

Nessa época, além de ser uma empresa do setor de gases industriais, a AGA fabricava periscópios para submarinos, telêmetros de artilharia e lentes especiais.

Oriundo de projetos militares de sistemas de imageamento noturno para tanques de guerra (imagem 02), o termovisores eram então uma solução totalmente nova como técnica de inspeção.

Cada unidade era constituída de uma câmera e de um monitor (na realidade um osciloscópio modificado - imagem 03). O projeto da câmera utilizava, além do detector, um espelho côncavo e de um espelho oscilante para a formação das imagens (imagem 04).

As medições de temperaturas eram diferenciais, ou seja, eram calculadas por comparação com um objeto de referência externo (e assim ficariam até 1985).

O preço, então, variava entre US$ 15.000 e US$ 20.000, alto na época (equivalente a mais de US$ 200.000 de hoje), assim mesmo, os equipamentos se pagavam em poucas semanas.

Suas especificações eram (compare com as de seu equipamento atual):

Foco:	**3m a infinito**
Campo de visão:	**5º x 5º**
Número de linhas:	**100 (algo como 10.000 pontos de medição)**
IFOV (aproximado)	**0,9 mRad**
Freqüência de imagens:	**16 por segundo**
Faixa de medição:	**-30º a 200ºC**
NEDT:	**1ºC**
Detector:	**Antimoneto de Índio**
Resfriamento:	**Nitrogênio líquido (-196ºC)**
Acondicionamento do refrigerante:	**Vaso de Dewar**
Duração do refrigerante:	**aprox. 4 horas**
Alimentação:	**115V ou 220V**
Peso da câmera / monitor/ total:	**17 kg / 20 kg / 37 kg**

As imagens térmicas eram apresentadas apenas em escala de cinza (positiva ou negativa - ver imagem 05).

A AGA Infrared Systems viria a se transformar na AGEMA Infrared Systems, que seria comprada na década de 90 pela FLIR Systems.

Em vários países o nome Thermovision*, transformou-se na linguagem técnica em "termovisor", uma merecida homenagem a essa série de equipamentos pioneiros.

* Hoje marca registrada da Flir Systems.

imagem 01

imagem 02

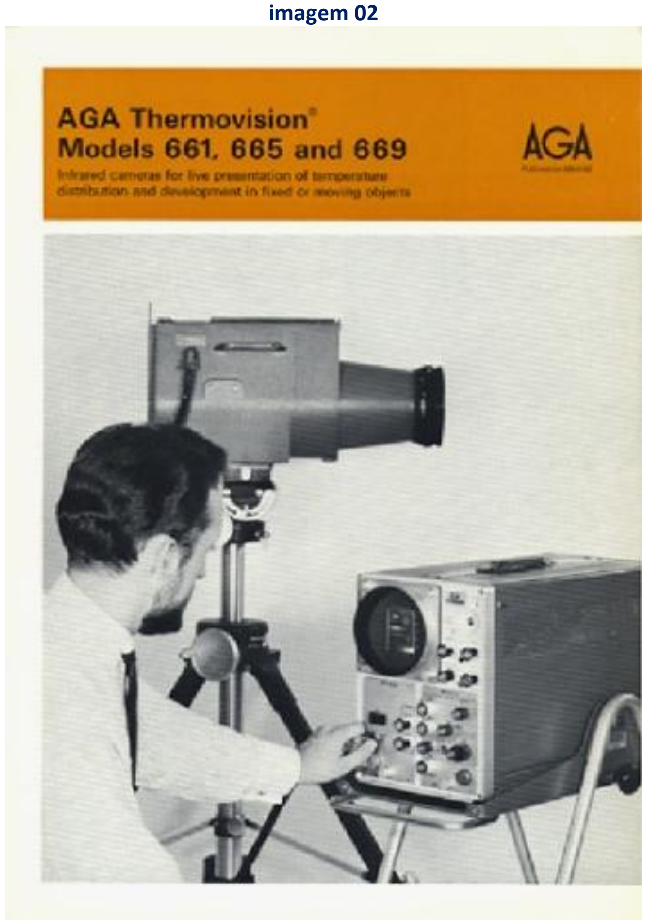

imagem 03

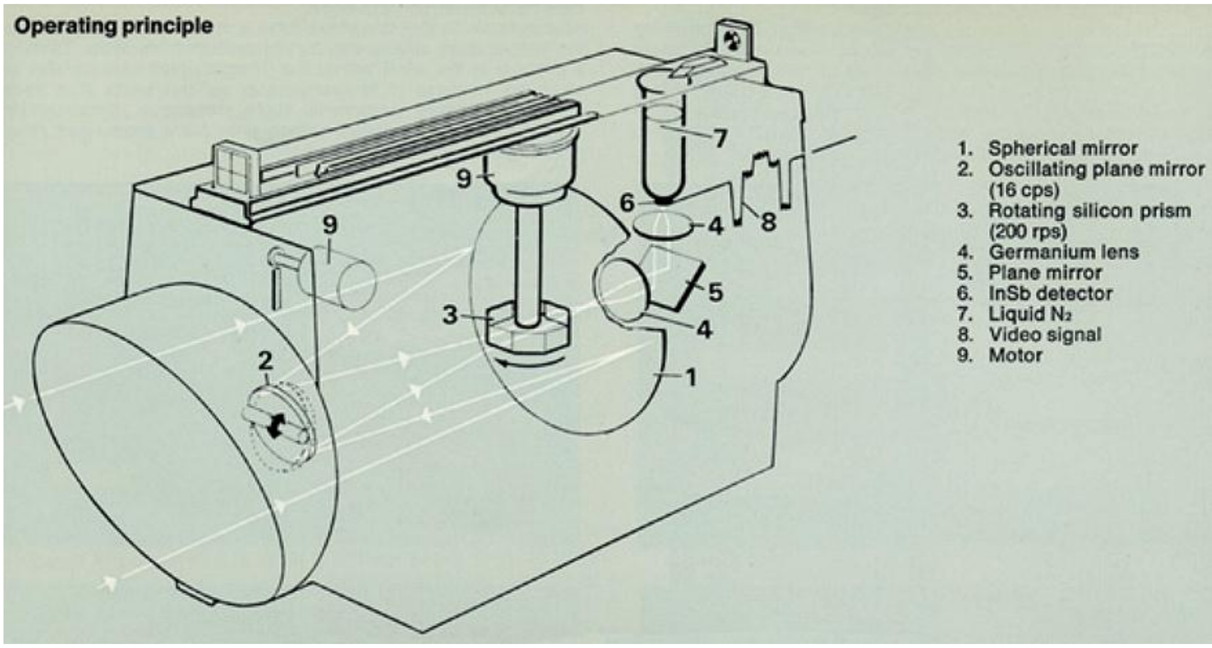

imagem 04

imagem 05

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Parte II

Recentemente encontramos em uma revista *Popular Science* de Julho de 1946 um artigo que demonstra que esse primeiro sistema infravermelho produzido pela AGA tinha suas bases em projetos da época da segunda guerra mundial.

O equipamento descrito no artigo a seguir era um projeto do Dr. Donald Andrews da Universidade Johns Hopkins, utilizando um interessante bolometro supercondutor de Nitreto de Columbio (Cb_3N_5), resfriado com nitrogênio e hidrogênio líquidos (ver notas 1, 2 e 3 ao final).

Pode-se notar a similaridade entre os desenhos do equipamento proposto e o lançado pela AGA, descontando-se as atualizações nas áreas de detectores e da eletrônica entre 1946 e 1964 (imagem 06).

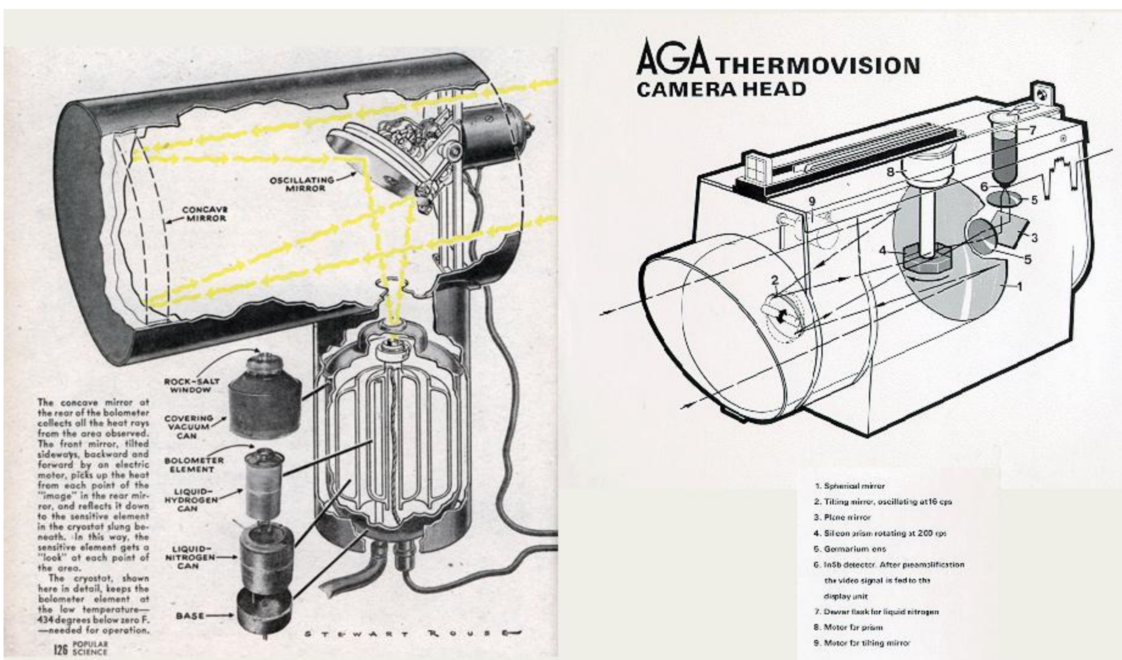


imagem 06

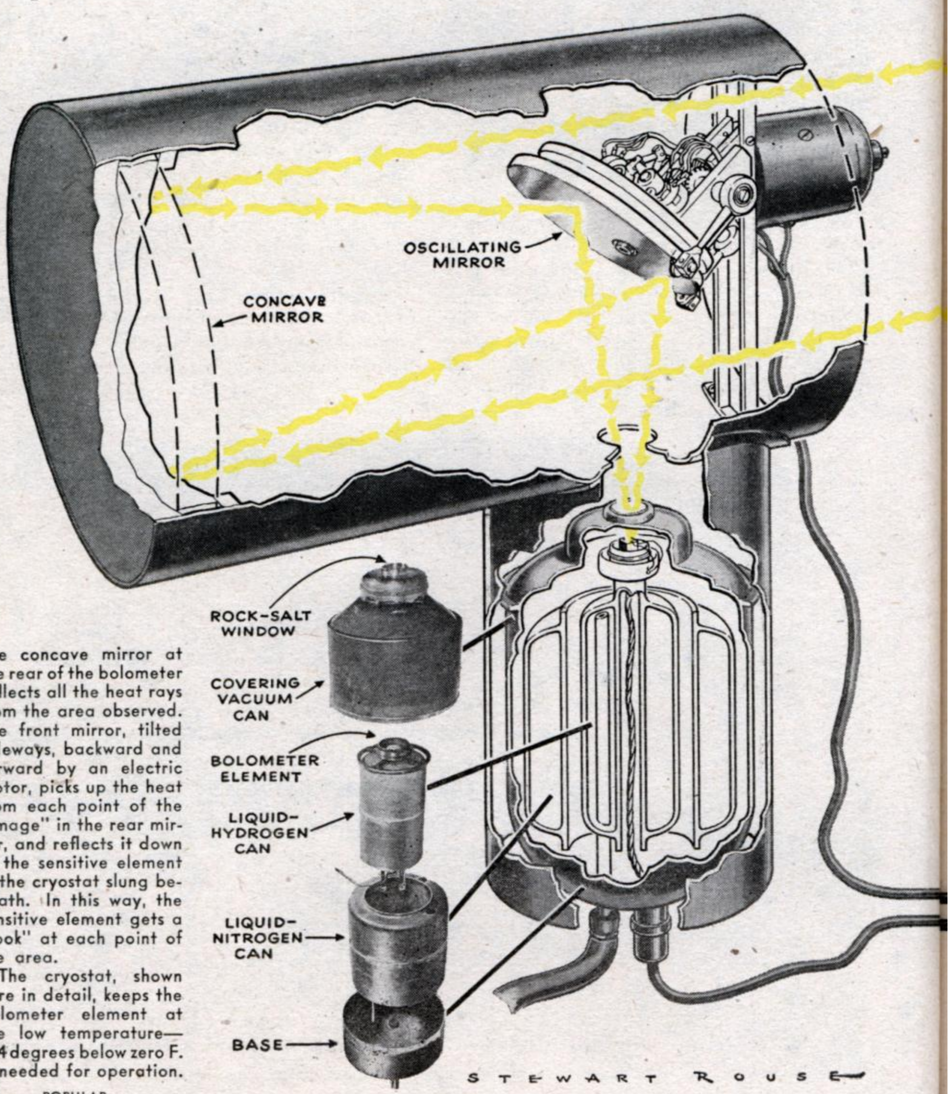
Várias aplicações da termografia são antevistas nesse artigo, inclusive as utilizações nas áreas médica, em veículos e na detecção de falhas em isolamentos térmicos.

Um erro nas previsões refere-se, no entanto, às projeções de custos dos futuros equipamentos. Ainda tomará algum tempo para os preços caírem da forma que era esperada.

AN EYE FOR HEAT

SCIENCE has outdone the cat with a new device that can really see in the dark. The superconducting bolometer, developed at Johns Hopkins University's Cryogeny (refrigeration) Laboratory by Dr. Donald H. Andrews and three student associates, will spot a truck moving in complete darkness five miles away—and instantly trace its outline on a screen.

Actually an ultrasensitive heat-measuring instrument, the bolometer detects heat radiating from men, vehicles, and buildings. Unlike the Army's sniperscope (PSM, June '46, p. 73), which reveals a night-hidden object



The concave mirror at the rear of the bolometer collects all the heat rays from the area observed. The front mirror, tilted sideways, backward and forward by an electric motor, picks up the heat from each point of the "image" in the rear mirror, and reflects it down to the sensitive element in the cryostat slung beneath. In this way, the sensitive element gets a "look" at each point of the area.

The cryostat, shown here in detail, keeps the bolometer element at the low temperature—434 degrees below zero F.—needed for operation.

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New bolometer that "sees" warmth miles away will help fight disease, warn of fire, catch burglars, and spot heat leaks.

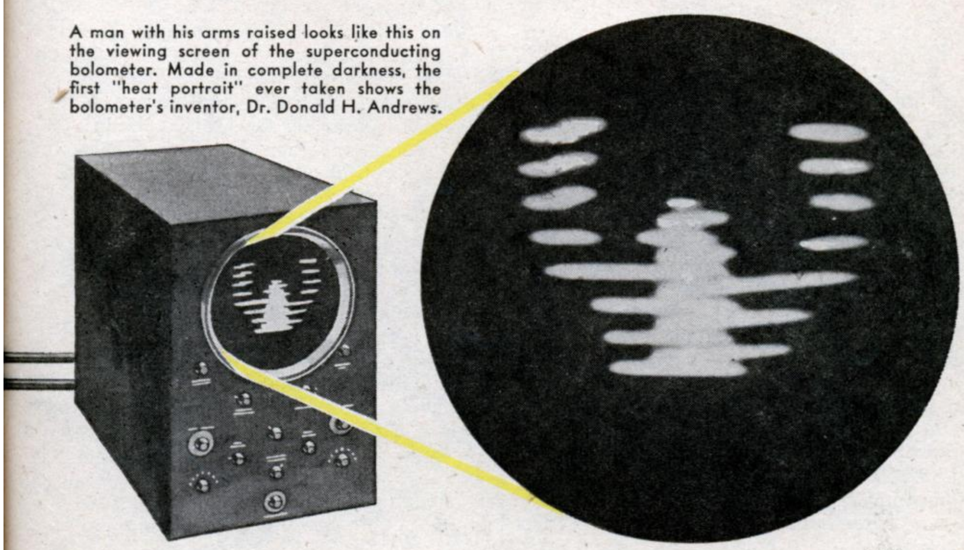
By MARTIN MANN

by sending out a beam of infra-red rays and showing on a screen the reflections from the object, the bolometer does not emit rays.

Like early television cameras, the bolometer employs a mechanically oscillated mirror to scan the area under observation. Instead of a cell sensitive to visible light, however, it has a tiny strip of alloy that responds to the invisible light of the infra-red spectrum—heat rays. This alloy—the rare metal, columbium, alloyed with nitrogen—converts the varying heat radiation it receives from the mirror into electrical impulses, which are amplified and fed into a cathode-ray tube. Movement of the cathode beam is synchronized with the oscillating mirror, while the intensity of the ray is governed by the impulses from the alloy strip—thus the object being observed appears on the fluorescent screen of the tube just as in a television receiver.

Its high sensitivity and quick action should make the bolometer valuable in science and everyday life. An instrument that can sense the heat of a truck five miles away might remove the danger from night driving. In a bolometer-equipped car, the driver would see a pedestrian or oncoming vehicle on a screen on the dashboard long before he could see either of them naturally.

The bolometer also might be used to detect heat losses caused by faulty insulation of buildings or equipment. Photographic film placed over the viewing screen would make a heat picture of a house, showing exactly where heat was leaking through walls and roof. And suggestions have already been



A man with his arms raised looks like this on the viewing screen of the superconducting bolometer. Made in complete darkness, the first "heat portrait" ever taken shows the bolometer's inventor, Dr. Donald H. Andrews.

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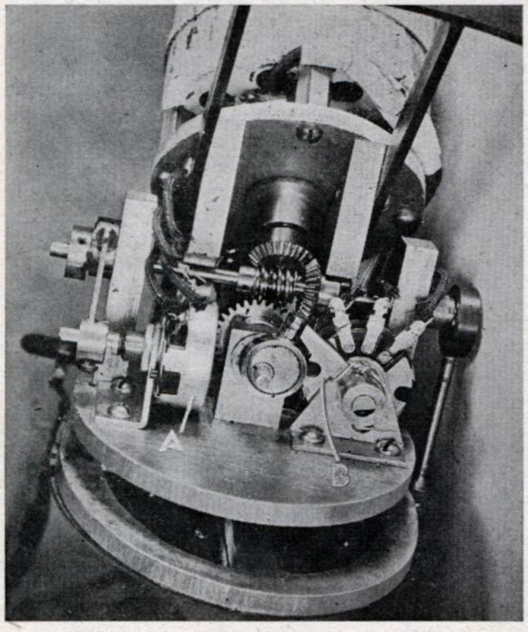
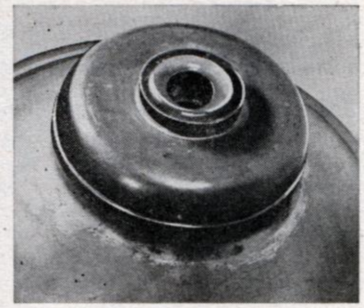
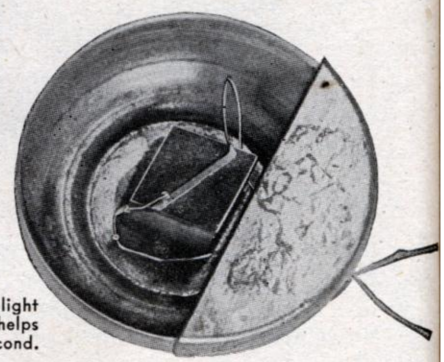


Looking down on the bolometer's electric motor and gears, which oscillate the forward mirror. Parts A and B are the two potentiometers that keep the cathode beam of the viewing scope synchronized with the oscillating mirror.



A rock-salt window protects the bolometer element, columbium nitride, for glass would not transmit all the heat rays detected. Maintained at 434° below zero F., columbium nitride notes a temperature change of one ten-millionth of a degree.



Copper post to which columbium nitride (light gray strip in photo at right) is fastened helps it react in three ten-thousandths of a second.

made for employing the bolometer in fire and burglar alarms.

But most important, its inventors believe, will be the use of the superconducting bolometer as a new tool in scientific research —particularly in medicine and physics.

For the first time doctors will have an instrument sensitive and fast enough to measure accurately the heat radiated from the human body. More precise analysis of body heat is expected to disclose additional information about the fundamental nature of disease and life itself. In physics, the bolometer will make more accurate investigation of the infra-red spectrum possible, and perhaps add importantly to existing knowledge of atomic structure.

Dr. Andrews will begin research this fall into the nature of heat radiations from sugar, fat, and other simple organic substances. Actual medical work, he estimates, can be started next spring.

The bolometer represents eight years' hard work. When Dr. Andrews, while relaxing on the beach at Nassau, first thought of using a heat-measuring instrument as a detector, it was merely a good idea and little more. There was then no suitable heat-measuring instrument. The existing bolometers used a simple platinum strip set in a balanced electrical circuit; thus a change in the temperature of the platinum, altering its electrical resistance, changed the current in the circuit. A galvanometer would then, in effect, register small temperature changes. But this bolometer was not sensitive enough to pick out a truck at five miles.

To improve the bolometer to fit his purpose, Dr. Andrews drew on 25 years' experience in low-temperature research. He knew the strange properties that matter acquires when cooled almost to absolute zero, the unattainable point 459 degrees below zero Fahrenheit where molecular mo-

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tion would stop completely. One of these properties—superconductivity—was eventually to solve his problem.

Low-temperature researchers had discovered earlier that electrical resistance—the "friction" with which substances oppose passage of an electrical current—suddenly disappeared in some metals when they were brought to a temperature near absolute zero. If a current were started circling through a ring of metal at superconducting temperature, it would continue indefinitely, provided the temperature did not rise.

Aware of this phenomenon, Dr. Andrews reasoned that an unusually sensitive bolometer could be made by maintaining the bolometer element just barely above the superconducting temperature. Since the drop from normal resistance to superconductivity occurs very suddenly, an element kept at this transition temperature would show very large changes in resistance for minute differences in temperature.

Assisted by Drs. Robert M. Milton and Warren DeSorbo, Dr. Andrews made the first superconducting bolometer by cooling a tantalum element with liquid helium. It was remarkably sensitive, but the apparatus was bulky and expensive to operate. Through diligent research, Dr. F. Hubbard Horn discovered that an alloy of nitrogen and columbium became superconducting at 434 degrees below zero F.—a temperature easily obtainable with liquid hydrogen, which costs only one-tenth as much as liquid helium.

In the present model, the columbium nitride element rests under a rock-salt window in the center of three concentric copper cans, called a cryostat. The inner can contains liquid hydrogen, the next liquid nitrogen, and the outer can a vacuum.

In operation, a small, steady electric current is passed through the columbium nitride element. Heat rays striking the element change its resistance and cause the electric current output to vary. These variations are amplified by standard, radio-type equipment and fed to a cathode-ray tube.

If the bolometer were mounted in an automobile, for example, the mirror would "look" from one side of the road to the other, shift down a bit and then "look" across again—in much the same way the human eye moves when reading. Whenever the mirror found an object radiating heat, such as a man walking in the road, its heat rays would be reflected to the bolometer element, which would convert them into electrical impulses.

The cathode beam, moving in synchronism with the mirror, shoots electrons at the screen when it receives an electrical impulse, causing the screen to glow at every point where the mirror found heat radiation. In that way, a zigzag outline of the man would appear on the screen. If the object in the road were another automobile, the engine, being hottest, would glow brightest.

As a detecting device, the bolometer is rather expensive to operate, since it requires about $8 worth of liquid hydrogen and nitrogen for every 24 hours' use.

The initial investment would not be great, however, since even the first, custom-made bolometers cost only about $100. And if they were to be mass-produced, Dr. Andrews estimates this would drop to $25.

Eventual elimination of the need for any liquefied gases, with resulting economies, is Dr. Andrews' present goal. He has already built the first model of the cryodyne, a refined mechanical refrigerating unit. The first cryodyne produced a temperature of 384 degrees below zero F., and Dr. Andrews expects that improvements will enable it to reach the superconductivity zone.

Dr. Donald H. Andrews watches the viewing screen of his bolometer. The miniature camera in front of him is used to photograph the images on the screen.

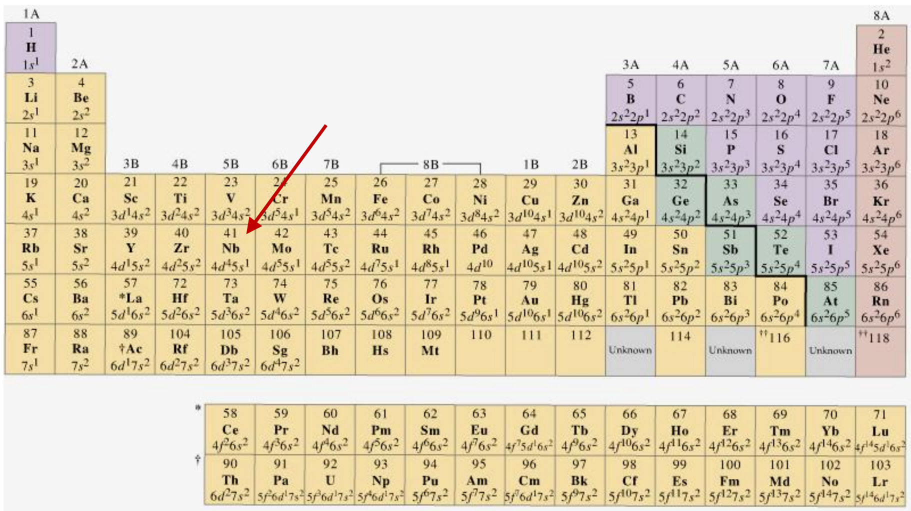
Nota 1: Quais as características desse detector?

O detector descrito nesse artigo é do tipo bolômetro (um detector térmico) com capacidade de medir variações de 10 milionésimos de grau Fahrenheit e um tempo de resposta de 0,03 segundos (tempo para o sensoreamento de cada ponto da imagem). Ao contrário dos equipamentos atuais, que utilizam arranjos de plano focal com milhares de minúsculos bolômetros (microbolômetros), nesse sistema um único detector deveria realizar todas as medidas da imagem térmica em conjunto com espelhos oscilantes.

Para informações adicionais ver o Artigo "O que é um Bolômetro" de 2009.

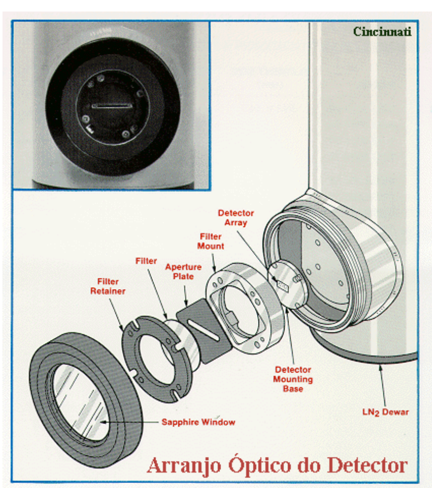
Nota 2: Colúmbio ou Nióbio?

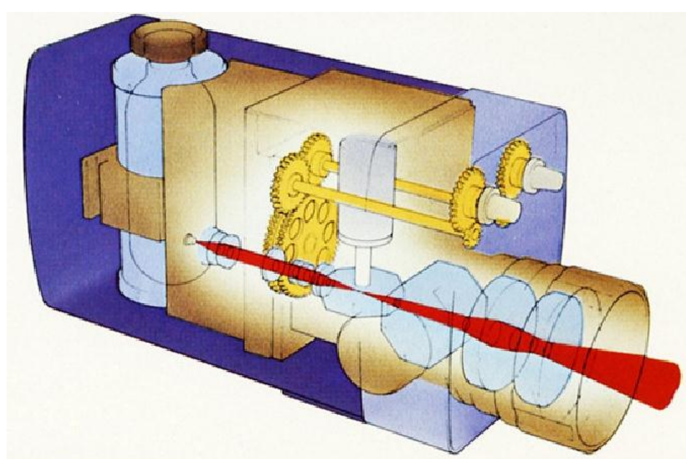
O artigo se refere a um dispositivo detector supercondutor de Nitreto de Colúmbio (Cb_3N_5). O Colúmbio, elemento de número atômico 41, era assim denominado nos Estados Unidos. Na Europa o nome para o mesmo elemento era Nióbio. Em 1949 a União Internacional de Química adotou oficialmente o nome de Nióbio (Nb), em deferência aos europeus. Atualmente o Brasil é o maior produtor mundial de Nióbio. A denominação Colúmbio ainda é utilizada por várias entidades nos Estados Unidos.



Nota 3: Detector térmico ou quântico?

Esse artigo descreve um detector do tipo térmico (detecta variações de temperatura). Quando a AGA lançou seu primeiro equipamento, em 1964, já estavam disponíveis os detectores de efeito quântico, nos quais a radiação interage diretamente com os elétrons do material provocando um sinal elétrico. O detector mais comum era o de Índio Antimônio (InSb), mergulhado em um frasco térmico contendo nitrogênio líquido (77K). Esses detectores dominaram o mercado civil até o barateamento dos microbolômetros, na segunda metade da década de 90.





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