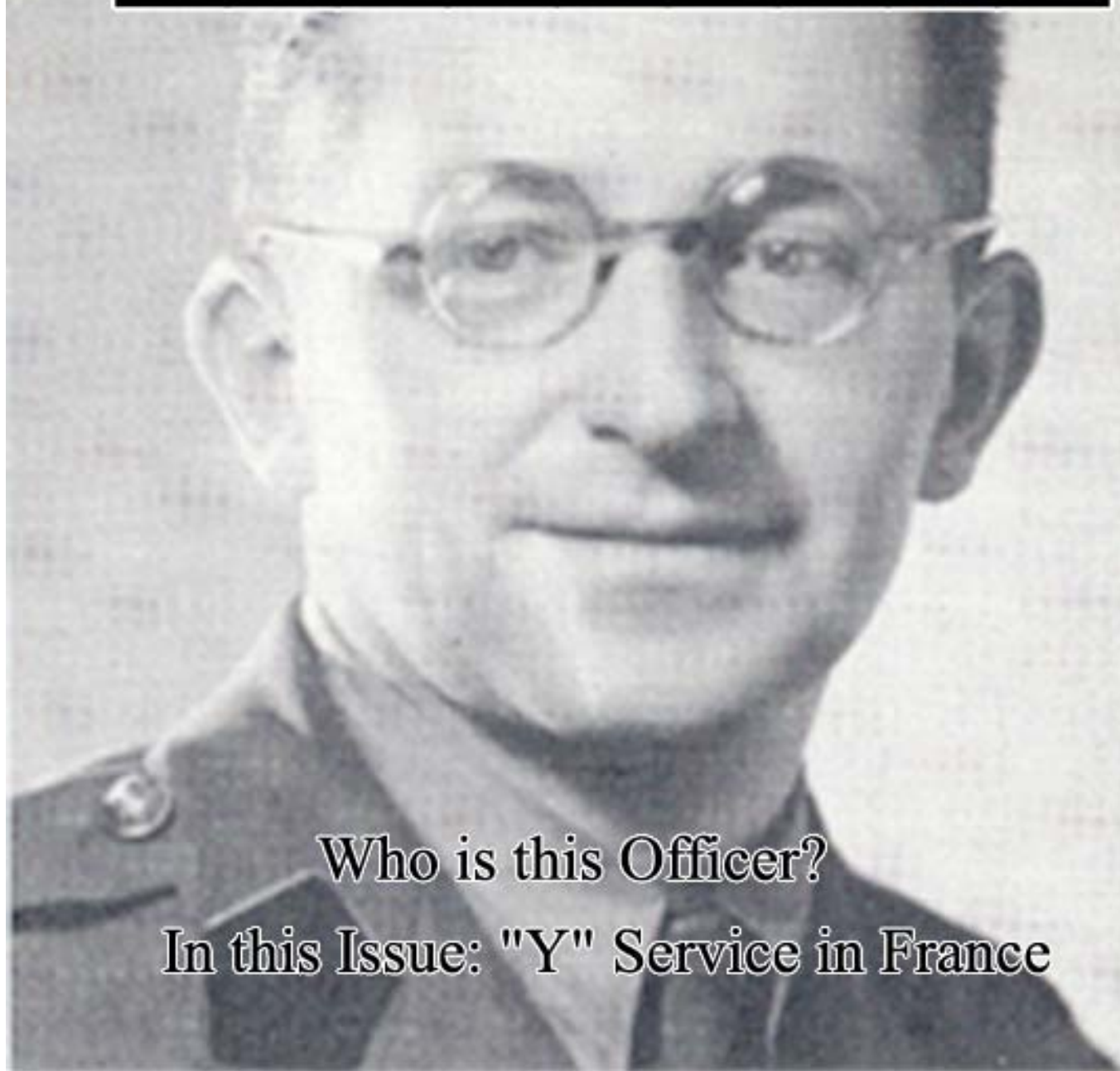


Syntonizer

Newsletter of S.P.A.R.C.

Keeping the Members in Tune

April, 2002



Who is this Officer?

In this Issue: "Y" Service in France

Syntonizer

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The Society exists for the purpose of preserving for future generations the electrical and radio-electronic communications artefacts that defined the 20th Century and to pass on the now rapidly diminishing expertise in their maintenance. Membership is open to all those interested in furthering those aims.

The Society operates a museum located on the campus of Riverview Hospital, Coquitlam, B.C. Call 604-777-1885 for up to date information on opening hours. Children are especially welcome. Special openings and extra display interpreters can be provided for large groups by prearrangement.

Tour and technical enquiries may be directed to the President. Enquiries regarding tax exempt financial donations and bequests should be directed to the Society's solicitors, Russell and Company, Suite 220, 4411 East Hastings Street, Vancouver, B.C., V5C 2K1.



Editorial Comment

“Y” Service

Radio, tube radio, brought the Allied Powers the greatest intelligence triumph ever. From the airwaves, the “Y” Services, particularly that of the Royal Air Force operating in England, intercepted German radio traffic. This input to Bletchley Park did not consist of mere gleanings but a full, rich harvest. Even early in the War, in 1940, its effect was decisive.

Churchill spoke about “The Few”. Everyone understood at the time the astonishing courage and endurance of Royal Air Force pilots who daily went up to tackle the largest, most modern and successful air force in the world in the late Summer and Fall of 1940. No air force in Europe had been able to stand against the *Luftwaffe*. Victories of annihilation had been gained in weeks. These men of the R.A.F., combined with the advantage conferred by radar and Camm’s design that could turn inside the Me109, it was said at the time, won the Battle of Britain. The Brylcream Boys and radar were only part of the story of the early British success against the Germans. There was another part to the story; a part hidden for four decades.

Directing, at the most senior levels, the activities of the Royal Air Force were those who had an almost complete order of battle of the *Luftwaffe* that was facing them and astonishingly detailed knowledge of its day to day activities. This knowledge came from the successes at Bletchley Park.

Our feature writer, Brian Lagden, was one of the other “Few”, that Few who were unacknowledged at the time and for so many years afterward. The Cold War continued unbroken the secrecy surrounding British methods and successes during the Second War. We owe no less to this second Few who sat hunched over their tube receivers copying the gibberish of German Morse cipher traffic hour after weary hour around the clock. On top of the effort required to copy nonsense code groups day after day was the fact that what use, if any at all, was being made of their efforts was unknown.

In fact, in that year of 1940, the Royal Air Force was just able to tip toe along the tight rope of success in intercepting the German formations. Without the extra “edge” provided by the knowledge of what was going in the *Luftwaffe* behind the scenes, the Royal Air Force would have ceded air superiority to the Germans. The R.A.F. would have lost the Battle not for want of courage and commitment but through sheer exhaustion of men and equipment. With “the news” from Bletchley, no profitless activity took place in the air.

Read about the manner in which this technological triumph, the “Y” Service, started and then wonder at how the Germans could have *lost* that war.

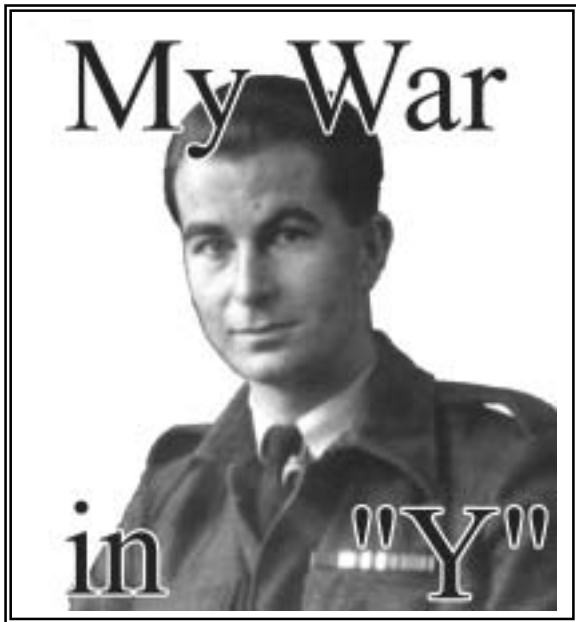
This Month’s Cover

The officer shown on our front cover this month had one of the most brilliant minds of the last century. His name is this month’s question. Who were his two equally brilliant colleagues and what do we own them?

Quathiaski Cove ☺

Quadra Island is on the *Syntonizer* map, Pal Horvath one of our readers is privileged to dwell in that Arcadia! He knows what Paul Wende was up to but he also

Continued on Page 7



By
Brian Lagden
 © MMII, Brian Lagden

This month:
Y Section AASF

A Pink "Flight"

After a few weeks training, our group of 50 or so recently mobilized reservists was due to embark for France in October; we did not get away until November; the reason was partly political and totally ludicrous: The Air Ministry "brass" were twitching because Bill M., who was contemplated for promotion to Flt./Sgt., had fought with the Government forces in the Spanish Civil War! That Government was (horrors!) *Communist!* - hence the official unease! Because "they" wanted to be reassured, Bill was summoned to London to be asked such penetrating questions as "Are you loyal?" What did they expect the answer to be *in any event?*

Hardening Up!

For three weeks, whilst Air Ministry was making up its collective mind, we, having been freed from watch-keeping duties pending embarkation, went on daily route-marches which normally consisted of about 5 miles actual march until we found a convenient "pub"; there we would stop for a few games of darts and to consume our box lunches along with liquids available on the premises!

Clandestine Departure

In due course, with Bill M., now confirmed as Flight Sergeant, in charge, we departed London's Victoria Station for our first destination, Dover, in a regular passenger train (we had a reserved coach clearly marked "Y Section AASF"!) full of holiday-makers bound for the coast.

Somehow, after what we had seen so far, my friend and fellow corporal Jim N. and I were not entirely surprised to find ourselves, at the last minute, man-handling a wooden packing case, containing a D/F radio, along the station platform to the baggage car, then getting ourselves aboard, at a full run!

Arrived in Calais, we were taken by "square-wheeled" S.N.C.F. train via Paris and Reims, through north-eastern France completing an exhausting 48-hour journey at our final destination, the little country town of Fismes. There, awaiting us at the local rail yard in an uncovered rail wagon was a load of antenna masts, clearly labeled "Y Section A.A.S.F., Fismes". So much for ~~Sieckrieg~~ **and Winterkrieg**

1939/40 was the coldest winter in my memory! The dry powdery snow blew in through the cracks in the uninsulated shiplap walls of our operating hut on an exposed hilltop. Two potbellied stoves, their sides glowing red-hot, were no match for that bone-chilling cold! Christmas Day 1939 found me wearing many layers of clothing, and a "balaclava", sitting in an open field testing a newly installed B/T Loop D/F Antenna! It was snowing, to boot, so soon commonsense prevailed and I pulled the tarp over the radio and went down to the billet for Christmas Dinner!

I'm not sure that we really ever did anything very vital at Fismes and we settled down to a fairly hum-drum existence all through the period of the so-called "phoney war" with occasional liberty trips into Reims to break the monotony.

Blitzkrieg!

Suddenly, *Blitzkrieg!* Our first indication that we were "in harm's

way" was the bombing of the rail yard about ½ ml. distant. For a few days we had been watching, with some concern, the stunning speed of the Panzers' advance. About the same time as the bombing, word came down from H.Q. that we should prepare to leave ASAP ("a bit sharpish-like" as our cockney Flt. Sergeant-Discip. used to say). Preparations started immediately, with the burning of Signals Office and other records in an old incinerator below my window: I can still see the rusty stove pipe flaring up and belching a smoke vortex every few seconds.

"Men and Horses First"

Later that day I witnessed a little "drama" which scarred my nineteen-year-old, somewhat idealistic, consciousness: The C/O was supervising the loading of most of the officers into the "staff car", one, Flying Officer N., having been detailed to stay and take charge of the "other ranks" during *our evacuation which was to be an hour or two later.* One officer, a recently commissioned P/O of about my own age, was refusing to abandon the "erks" when our intrepid C/O, a Squadron Leader who shall be nameless, exclaimed "*Get in the car, you fool and get out while you can!*"

I think I grew up several years in those few seconds; obviously not everybody was the Boy Scout I had been only recently! To his credit, young P/O "G." stayed with us right across France and eventually to R.A.F. Locking near Weston-super-Mare.

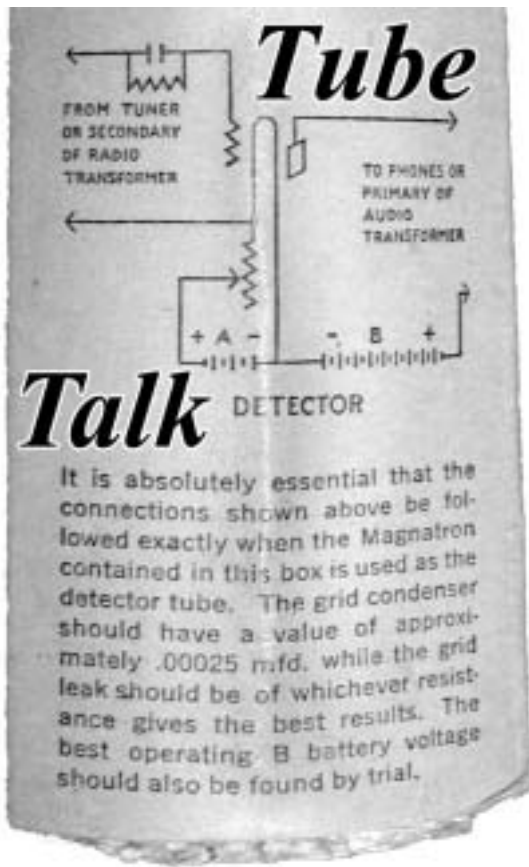
Frigid Farewell

The C/O did show up at *that* location, to bid farewell to the troops, since he was to be promoted Wing-Commander and given command of a large Signals Wing! When he finished his address, during which time everyone remained stone-faced and silent, the Flight Sergeant, having asked permission, called us to attention and, with a smart salute, dismissed the parade, which broke up in utter silence.

Tactical Withdrawal

Our trip home had not been without incident. We started off,

Continued on Page 7



With
Neil Sutcliffe, Tube Troll

The Ubiquitous Triode

In the electron tube world, the simple triode is the first of the amplifying types and it is adaptable to a wide range of applications. While the triode has several drawbacks, it also has many advantages, so, while being the first practical electronic amplifier, it is still being produced for several specialty applications to this day.

RCA and Bell Labs Dominate

To keep this article a reasonable size, I shall confine the discussion of the triode to mainly North American progress since it tended to be the leader in advancements (though by no means always) while the rest of the world tended to follow. This is perhaps because the electronic design field was dominated in North America by two major industrial enterprises, RCA for radio systems and AT&T/Bell Labs
S.P.A.R.C. Syntonizer, April, 2002.

for land line communications (audio). Each of these enterprises decided what electronics was needed to achieve their goals of the moment and then applied the required resources to develop the circuits and components (including tubes) needed to achieve them. Small independent companies and designers could never hope to compete with this, although Armstrong and Hazeltine both developed many original circuit concepts.

Gridded Audion

The triode began humbly as an experiment, in early November 1906, by Lee deForest, to make an improved detector. He found that by putting a metal sleeve or a coil around a 'Fleming valve' and connecting this external element to the antenna circuit, there was a modulation of the current flowing in the filament/plate circuit. As a second experiment, a second plate was added to the valve on the opposite side of the filament from the original single plate, and, when this was connected to the antenna circuit, a greater modulation of the 'normal' plate current occurred. He conjectured that by placing this plate between the filament and the 'normal' detector plate, the effect might be even more pronounced, but he felt that placing a solid plate there would block the flow of "particles" from filament to plate, so he determined to form it from a serpentine of fine wire. In late November these new detectors were ordered from McCandless (a scientific lamp maker). At this point, deForest was fired from the deForest company with only \$500 and his patents as severance. It was not until December 31, 1906 that this first gridded Audion was finally tested by a high school student helper, John Hogan Jr. The results were hugely successful and a patent was applied for by January 29, 1907. Thus the triode was born. By March this version of the Audion was in production. It was a screw base spherical globe about 2-3" in diameter with the grid and plate leads coming out the top opposite the base.

AT and T's Bell Labs Takes Over

While this Audion was intended primarily as a detector for radio, deForest did work up a design as an audio frequency amplifier, and, although it was seriously flawed, it was offered to AT&T in October 1912. During the development of this circuit, deForest found that it would 'howl' and had unwittingly proved that the Audion would oscillate. The AT&T engineers who looked at his amplifier design realized that although the example presented was useless to them, the concept had great potential and they bought the rights from deForest.

Trans Continental Voice Circuit

Immediately, Dr. Harold Arnold spearheaded the development of a workable, reliable triode amplifier system for telephone long distance repeaters. By mid 1913 he reported "we had a high vacuum oxide cathode triode operating to 200V plate with a 1000 hour life". In October the same year, there was a field trial in commercial service on a New York to Washington toll circuit of the first ever vacuum tube amplified telephone repeater. By January 1915 a string of improved repeaters was installed for the first trans continental telephone line from New York to San Francisco.

"Massively Parallel"

Also, in 1915, a series of tests was conducted with a transmitter in the US and a receiver in Paris to study the reliability of trans Atlantic radio communications for telephone service. The US transmitter used a 101A as oscillator, driving 550 parallel 204B triodes specially designed for the test. This transmitter ran at 600V and 175A for an input of 55kW.

From here to 1920, at AT&T, there were numerous improvements, mainly for the military communications needed in WWI and primarily an improvement in power rating and reliability. A glut of this war surplus equipment and triodes appeared for the amateurs by 1920.

Alternator Modulation

Parallel to this AT&T development, but on the radio side, Reginald Fessenden (a Canadian) was experimenting with voice

modulation of an RF carrier. He designed a high power rotary alternator to directly generate the RF with the intention of modulating either the excitation or the actual RF current. He had the alternator built by GE but they would only warrant it up to 10kHz, not the 100kHz Fessenden required. GE put E.F.W. Alexanderson on developing a better alternator which was ready in 1913 and ran at 200kHz. They sold one to John Hammond, and while commissioning the unit at Hammond's, Alexanderson spoke with an employee, Ben Miessner, who suggested using an Audion as an amplifier. Alexanderson took one back to GE and Irving Langmuir was set the task of developing it for RF oscillation and modulation. On March 13, 1913 a super high vacuum was achieved and the test tube was found to perform well as both an RF detector and an amplifier with plate voltages up to 235V. Dr Dushman took on the task of further developing the triode, pushing it to 10,000V @ 100mA, and in May 1914 used it successfully as an RF modulator for the Alexanderson alternator.

Pirate Tubes

In 1911, Wallace & Co. marketed an Audion (made by McCandless) as 'the Wallace Detector', and became, as was said by E.H. Armstrong, "the original tube bootlegger". In March 1916, E.T. Cunningham began production of a cylindrical triode, the 'Audiotron', in Oakland, CA. It was about 5/8" dia x 3 1/4" long with leads coming from each end.

RCA Takes Over

With the end of WWI, the US Government did not want international radio communications to fall back into the hands of the British Marconi company, so in a complicated series of transactions by GE (backed by Washington) the assets of US Marconi were transferred to a new corporation, RCA in 1919. This included all the deForest patents and soon RCA was suing all the infringers such as Wallace, Cunningham and others. A deal was worked out between RCA and Cunningham in which he would cease production

and would, in future, sell GE made tubes supplied by RCA and marked "Cunningham" until, at least, 1926. In fact, this carried on until 1930 when Cunningham was bought out by RCA, and is why RCA tube manuals were designated as RC-xx for RCA/Cunningham.

Broadcast Receivers

RCA, as holder of all the important patents in radio electronics, began serious development of radio circuitry and tubes at the GE and Westinghouse labs. The first new types for general use were brought out in 1920, the UV-200 and UV-201. While identical in structure the '00 was a detector with some back filling of gas, while the '01 was an amplifier with a high vacuum. These were sold for "amateur and experimental use only". With the advent of Broadcasting by Westinghouse in 1921, considerable development ensued to make the triode economical and efficient for use in broadcast receivers, such as the Westinghouse WD-11 used in the Aerola Sr.

Thoriated Cathode

GE developed Thoriated Tungsten for use as filaments and were able to produce the UV-199 and UV-201A which were much easier on battery consumption. The UV-199 would operate on a single dry cell. In mid 1925 the UX-112 and UX-120 were introduced to provide higher power output. The UX-240 was a 'super' '01A and was the last DC filament triode developed in the '20s. From 1926 there was a demand for AC filament triodes for use in 'mains' operated radios, and in 1927 the UX-226 was introduced, functionally like the '01A, but with a 1.5V/1.5A AC filament. This worked well for the RF and Audio amplifiers in the sets, such as the Radiola 17, but was useless for the detector, because the filament with AC on it introduced too much hum in that ultra-low level stage. To solve this, H.W. Freeman at Westinghouse submitted a double ended, indirectly heated triode in July of 1925, and this was designated the UX-225. A 5 pin base was suggested to "single end" this tube and this was introduced as the UX-227

in April 1927. In March 1929, a medium power output triode was introduced, the UX-245.

Sophisticated Designs Appear

So, at the end of the '20s most basic triodes had been developed and radio design was trying to wring the most out of these, especially since the depression had begun and radio sales were falling due to the high prices of current sets. The appearance of Armstrong's Super-hetrodyne had the potential of vastly reducing the cost of receivers, but not using triodes. The '30s heralded the arrival of the multi-grid tubes with their special features, while the triode remained to be used in those applications where it was still superior.

Short Wavelengths

During the '30s there was considerable progress on increasing the frequencies that could be used. By 1933, twin triodes were operating transmitters up to 750cm and by 1934 the Acorn triode, with its microscopic triode structure, was functional to almost 1GHz.

Early in the '40s, WWII was requiring high power transmitters and low noise front ends for 2 metre and higher radars, and here the triode did yeoman work.

Other than these high frequency RF applications post-war, in FM and Television (for which the ultra miniature 'Nuvistor' was developed), the triode was mostly relegated to oscillator and low frequency/low power audio applications. The major players being the 6C4, 12AT7 (RF), 12AU7 (mid power), and the 12AX7 (high gain) and all their various repackaging.

Triodes Displace Relays

One other application that consumed huge numbers of triodes (typically 6SN7 and 12AU7) was in the 'flip-flops' of the first electronic digital computers developed through WWII, and only supplanted in the latter '50s by the triode transistor.



Station Break

with
Peter Trill

[It's disappointing to have to report that Peter has been unable to find time over the last three months to write his column. We all hope that over the next three months he will be able to find time for the Syntonizer. Ed.]

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It's an ill wind that blows no good and the unexpected absence of Peter's copy this month allows the luxury of publishing an excellent letter.

A Letter and a Good One

Rick Leipter (VE7HRL) has written us a great letter. As you heard last issue, publishing letters on a regular basis is just not possible because of the minute space we have available. Only the first part of Rick's letter, the technical part, will be published verbatim because of space. Rick had some suggestions later in the letter for the *Syntonizer* and they are good points, they will be dealt with, too, because they will have occurred to other readers.

Text

Here's the first part of Rick's letter. Read and heed from one who knows:

Sir:

My compliments for your work on the Syntonizer. It is lively and interesting.

The picture of Paul Wende working away reminds me of the days when I ground crystals. While I don't consider myself an operator (more an experimenter), I have

S.P.A.R.C. Syntonizer, April, 2002.

practiced that art. Toothpaste was a final material we used when you were "gettin' close". I don't remember the brand but it had a fine grit that produced a smooth polished surface and removed a very small amount of crystal material so that you didn't overshoot the target frequency. The whole routine was rather cumbersome where you ground, cleaned, put the crystal back in its holder, checked the frequency, removed the crystal and ground some more until you got to the desired frequency. Not the type of thing that goes over well with our present day, instant gratification society!

... Rick's Suggestions and Observations

Internet Communication

Rick suggests using email to advise on membership expiry and to distribute the *Syntonizer*. That matter has received substantial thought. The very large difficulty is our "demographic". Many of our readers are not computer literate and others are not computer users for financial reasons. Of the rest, most would be using dial up modems and not be able to take an email of some 1.8 megabytes or even to download such a file from a website. A further complication is tracking who should get what and keeping those records up to date; we have no secretarial support.

Publishing on the web brings us the difficulty of some members being more equal than others. People are paying dues, among other things, to receive the *Syntonizer*. Everybody pays the same amount; everybody should receive the same service. It's on that basis that the *Syntonizer* is being mailed out exclusively on the publication date right now. By the way, thanks to our new webmaster *back issues* are available on the web at http://www3.bc.sympatico.ca/radio_museum/news.html .

The matter remains under active review and opinions on the vasty moral and ethical implications of web publication are most welcome!

When thinking the matter through before writing, please consider that what we would not like to do is to relegate our large number of mail receiving readers to second class status by having them receive a "dated" *Syntonizer* a week and a half after an *élite* connected to the internet has received it or to discover, say, that they can't participate in some late night QSO with all the other grumpy old men on 80m because their *Syntonizer* comes by snail mail! Their museum must not see them "left behind" by the internet.

Go ahead, persuade your editor, he's listening.

Amount of Dues

In the last issue, Rick points out, as have others, that the amount of the dues for the coming year had not been published. That was not an oversight on the part of the editor.

Long and hard pondered he the matter and finally concluded that if he were to put a figure into the *Syntonizer* (required by law to be published many weeks before the a.g.m. because it contained the notice of that meeting), the executive would have decided by meeting time to raise the amount! We would then have a devil of a mess with some people having sent in the old amount, some people arriving at the a.g.m. prepared to pay the old amount for the new year and flourishing their copies of the *Syntonizer* in Paul Johnson's face to prove their point and new people now being unwilling to pay the extra since some had got away with paying the old amount. A Solon would have been required to sort out the ensuing mess.

Probably the executive would have ended up being compelled to abandon an increase and on top of that then obliged to undertake a bookkeeping exercise to provide credit to those who, by a.g.m. time, had made overpayment for the coming year in anticipation.

It was simpler to say, essentially, come out and pay up!

Rick, thank you for your letter!

Editorial Comment, continued

knows what only the old timers know. The technique of crystal grinding was at its apex in the tough times of the 'thirties. A dollar was important money to those who grew up in those years. There had to be a good reason to spend a dollar and crystal grinding was not among those reasons. The abrasive to use was not something that one had to go out and buy but common, ordinary, tooth powder or tooth paste.

Others who understood were Peter Trill, Brian Lagden (f8BL), Denis Livesey (VE7DK).

Rick Leipter (VE7HRL) understood and wrote such a great letter on that subject and on other matters that readers will find it published in this issue of the *Syntonizer*.

Small

Ours is a small organization. One of your editor's duties to his readership is to prevent the newsletter becoming "small". Have confidence. The *Syntonizer* will not degenerate into a catalogue of exhortations, entreaties, adjurations and admonishments under this pen. You won't keep hearing about the doings of an "in" group at the Museum either. The executive members seem to be of the same mind so we have a good thing going. Each issue, just open, read and enjoy!

The All Red Route

Your museum is a repository of radio equipment from the last century but it is not confined to that role.

We also have magnificent, and that *is* the right word, equipment from the world's premier, globe girdling, cable network of a hundred years ago. It was the "360 Networks" of its day.

Miniposter

Big trucks sell. Back in 1924 the copywriters understood that. Broadcast radio was a two year old baby in 1924 but have a look at that art and the associated copy: real men buy from Kellogg Switchboard! We of the new century are still looking at the same advertising ploy!

My War in "Y", continued

generally Westerly, aiming for Le Havre (Dunkerque was out of the question) but the Panzers' advance was so rapid that we quickly abandoned that idea! Cherbourg was rejected out of hand (no point getting cooped up in that peninsula!) and we wound up at St.Nazaire near the mouth of the River Loire

Force of Character

It was here, right at the dock, that we were very grateful for the presence of the occasionally somewhat abrasive F/O "N."; - about half of our unit were already boarded on the M.V."Sobieski", when the Embarkation Sergeant held up his hand indicating that a full load had been reached, meaning that the rest of us would have to take the next ship. F/O "N." managed to persuade the NCO that there were "only about twenty" of us and we'd like to keep the unit together. Had we been excluded, we should have been on the ill-fated "Lancastria" which received a bomb straight down her smoke-stack and sank, in minutes, right in the roadstead!

Near Misses

We did have a little excitement right in Ste.Nazaire harbour, in the shape of near misses from bombs dropped by a couple of captured (and enemy-operated) Hurricanes still wearing their RAF roundels! [This incident is a subject of discussion, ed.] After that, the weather being glorious, we had a pleasant and uneventful trip, via Falmouth, to RAF Locking. From there we were sent on a few days leave with instruc-

tions to report back to 61WU Cheadle whence we had started

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Paul Johnson's "Do's and Don't's"

DO remember that S.P.A.R.C. is a self supporting preservation society. It needs your support and participation in its endeavours.

DON'T forget to visit and bring a friend.

DO bring in clean rags for use in the Museum's main entrance.

DO donate small hand tools.

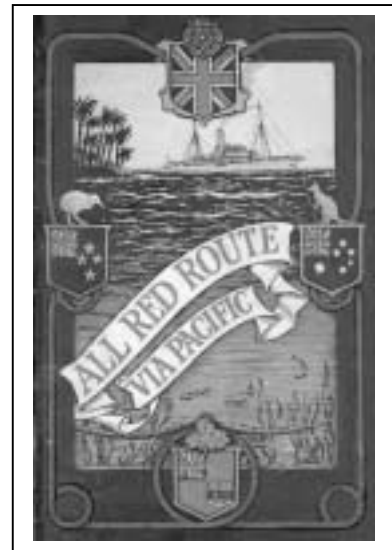
DON'T forget to pay your 2002 dues before March 1st, 2002.

DO find out a place where S.P.A.R.C. needs help.

DO advertise our C.D. program. See Jack Watson.

DO advertise our group tours, talk to Paul about that and new memberships, too.

DO hams please come in and keep VE7CHR active. We should be on air often.



ANOTHER CENTENNARY IN COMMUNICATIONS

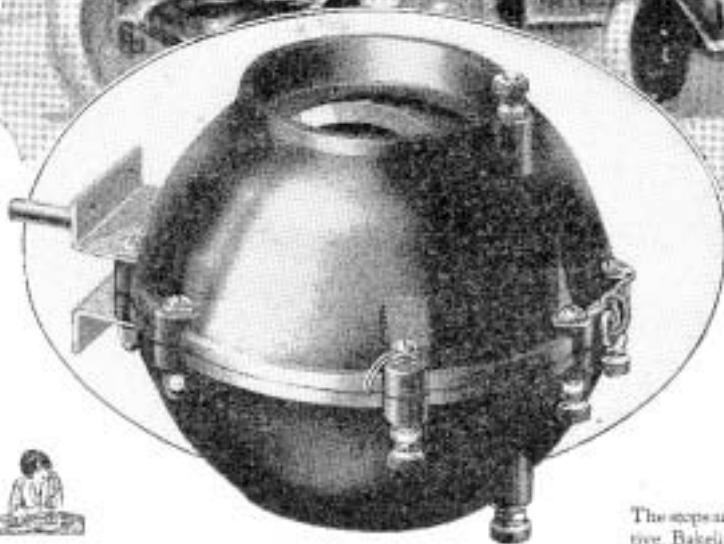
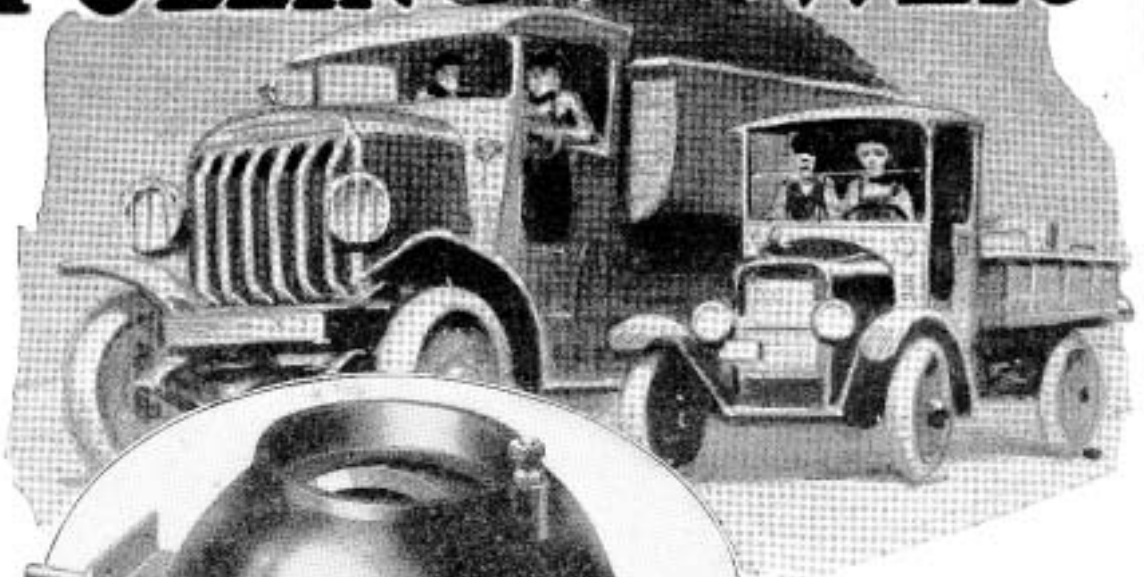
In 2001 the world celebrated the 100th anniversary of Marconi's trans-Atlantic communication. A mere year later we are poised to celebrate another milestone. It was in October of 1902 that the first trans-Pacific communication took place. The medium was not wireless but underwater cable telegraphy. The world's longest single span of undersea cable was completed linking Bamfield on Vancouver Island to Fanning Island in the south Pacific.

The cable then went on to terminate in Australia and New Zealand. This allowed government and commercial traffic from England to reach the south Pacific in a matter of hours rather than weeks. It also strengthened England's grip on its empire. The cable relay stations were built only in countries that were part of the Dominion. As world maps of those years showed the British Empire as red coloured, the cable link became known as the "All Red Route".

This fall SPARC is planning to commemorate this feat. Planning meetings have already taken place between a group in Australia, Porthcurno Cable and Wireless museum in England and SPARC here in Canada. We also invite former employees that worked on this system to contribute any memoirs they might have.

Stay tuned for further updates as this event progresses!

PULLING POWER



Heavy Bakelite shells of rich brown color. Windings of correct gauge wire and properly proportioned for best reception. Large bearings assure smooth operation and long life. No sliding contacts; rotor connections made with special flexible wires, through hollow shaft to binding posts on stator shell.

The screws are a part of the stator and rotor and are positive. Bakelite especially treated to prevent distributed capacity. Arranged for either panel or base mounting.



VOLUME!

THE variometer or variocoupler is responsible for the strength of the signals received. Therefore, the size, shape, gauge of wire and number of turns in the Kellogg variometers and variocouplers are the result of exhaustive tests for equipment that will give the best radio reception.

Therefore, it is to your advantage to demand Kellogg variometers and variocouplers and know that you will receive better reception, resulting in maximum entertainment, and value from your radio set.

If your dealer does not handle Kellogg, communicate direct with us,

KELLOGG SWITCHBOARD & SUPPLY CO.

1066 West Adams Street, Chicago

Museum Library, Wireless Age, 1924