Calculating for Profit[1]

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Instead of just calculating the profit, a specialist slide rule was the reason for the profit!

The Chicken or The Egg?

Before the electronic pocket calculator became dominant, the mathematical roots of the slide rule meant it was universally used for a wide variety of scientific, navigational and commerce-based calculations. For certain trades and disciplines specialist slide rules or scale arrangements were marketed. For example, most mainstream slide rule manufacturers offered at least a speciality "Electro" and a "Chemical" slide rule alongside their standard Mannheim, Rietz and Darmstadt style offerings.

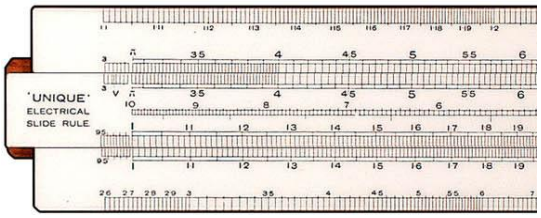


Fig. 1: **Unique Electrical**

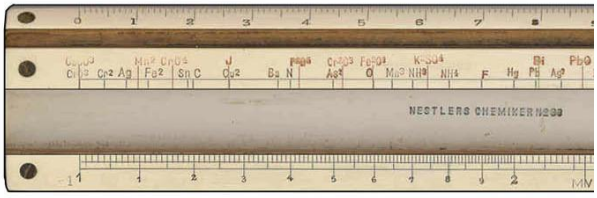


Fig. 2: **Nestler 33 Chemiker**

But like the riddle of whether the chicken or the egg came first, one well-known company innovatively turned slide rule convention on its head. Astutely Shell (Royal Dutch Shell plc since 2005) realised that having its own specialist slide rule would, in itself, generate extra profit.

A New Era

In The Netherlands, and across most of Western Europe, around the late 1950's and early 1960's, heating oil (Gas Oil - *"Shell Huisbrandolie 1"* or *"No. 2 Heating Oil*" in the USA) was rapidly becoming the favoured fuel source for modern central heating systems. Many Dutch households were tired of the dirt and dust of storing and fuelling their coke-fired heating furnaces. So they were keen to switch to the better performance and convenience of a new oil-fired system [1].

Fig. 3: **Coal/coke furnace**

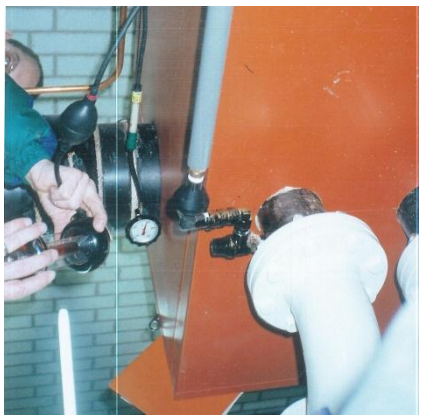


Fig. 4: **Oil-fired central heating**

[1] Revised and extended version of a short article first published in Dutch in the *"Mededelingen en Informatie voor Verzamelaars van Historische Rekeninstrumenten (MIR)",* Number 44, April 2007.

Shell Nederland Verkoopmaatschappij B.V. (SNV) is the sales and distribution arm of Shell in The Netherlands. They spotted the new trend early on and quickly made it a company objective to become the leading supplier for the developing home heating oil market in The Netherlands. They thought they were well placed to gain a dominant market share because they already had considerable in-house experience and expert knowledge about oil-based furnaces. But there was a conflict of interests – SNV had a team of furnace/boiler experts on their payroll but all of them were fully occupied advising various important large industrial customers.

So in the early 1960's SNV decided to form a new team of advisers that would exclusively court the expanding home heating oil market in Holland. However, the scope of the team was extended to include churches, shops, retirement homes, etc. A market segment that is today best categorised as "SOHO" or the "small office-home office". The team started by making a series of familiarisation visits to the main boiler and tank manufacturers. The companies they visited provided each of them with a rich library of documentation. They also learnt about the associated control equipment (e.g. thermostats) and how to measure and assess the efficiency of oil-based central heating systems. The familiarisation visits and the private libraries were to prove invaluable. This is because the inspectors quickly found out that they needed to be up to speed with all the leading heating equipment of the day and be able to evaluate "conflicting" proposals made by the competing installers [1].

Grabbing Market Share

In parallel to the setting-up of the initial 12-man team, Shell successfully negotiated exclusive cooperation agreements with three of the biggest suppliers of central heating boilers in Holland:

- *REMEHA B.V.*, Apeldoorn (still in business)
- *PSK* - PlaatStaalKetel (no longer in business)
- *Ideal Standaard*, Venlo (still in business but no longer in heating)

and the biggest Dutch supplier of home heating oil tanks of the day; *SPIN*. Next Shell approached the main installers of central heating systems. Many of these signed similar cooperation agreements. With these agreements Shell got advance warning of all the boiler and tank deliveries and all households/SOHO's receiving a quote for converting or replacing their existing heating system. In return, SNV agreed to pay a "finder's fee" whenever a prospect from a supplier or installer signed a delivery contract for Shell Heating Oil. For a maximum of five years, the fee paid was 2.50 gulden for every 1000 litres delivered to the same location within a 12-month period.

The work of the 12-man team was split into two groups of four and eight. The task of the smaller group of four managers was to keep in contact with the boiler/tank suppliers and the central heating installers so a steady flow of address information flowed through to the other group. The group of eight "Heating Oil Inspectors" (as they were known) made all the visits and were equipped by SNV with:

1. an impressive information binder
2. a specially fitted case with equipment for measuring CO_2 levels, the temperature and the soot content of the exhaust gasses in the flue
3. a specially commissioned central heating efficiency slide rule

Based on a constant flow of "hot prospect" addresses, the inspectors would arrange to visit the households/SOHO they knew were considering a new heating oil-based central heating system or intended to switch their coal/coke furnaces to oil firing. As part of their initial visit, the inspectors would leave behind some marketing folders and make a point of explaining that if the prospect signed up for Shell Heating Oil, they were entitled to valuable expert advice. For example, if more than one proposal was being considered, the inspector would independently evaluate them. They would also return after everything had been installed and free of charge:

- check if the new equipment had been installed correctly,
- assess if the set-up was running efficiently i.e. check that no mistakes had been made and that they would not have to buy more fuel than they needed to.

At the time, the price of heating oil was strictly government regulated and fixed. So the free advice and free assessments were an innovative and appealing part of the SNV promotion drive. It was a unique selling point that made SNV stand out from all the other heating oil suppliers as none of them were allowed to undercut each another on price.

Fig. 5: **example of a fitted case (39 x 35 x 10.5 cm) with measuring equipment supplied by Royal Econosto Group, Rotterdam – a wholesale supplier (still in business) of engineering equipment**

SNV Central Heating Efficiency Slide Rule

If a household/SOHO signed up for Shell heating oil they almost always asked for the complimentary assessment. The most important factor in assessing the performance of any central heating system is its yield or output efficiency [2]. However, assessing the associated combustion performance (or the fuel burning efficiency) is not straightforward, even for experts. But the inspectors had the special white plastic duplex pocket slide rule (190 x 27 x 6 mm) commissioned by SNV. This made light work of all the complex calculations involved.

The SNV slide rule is special for several reasons – including the reversal of what is normally accepted as the front and the back! What looks initially like the back of its solid frame construction, is in fact the front face and needs the cursor. The give away clue is the backward slant of the bevelled edge 0-17 cm linear scale on the top edge. So surprisingly, the sliding double-sided slide is only used with the scales on the back face - that in turn does not need a cursor.

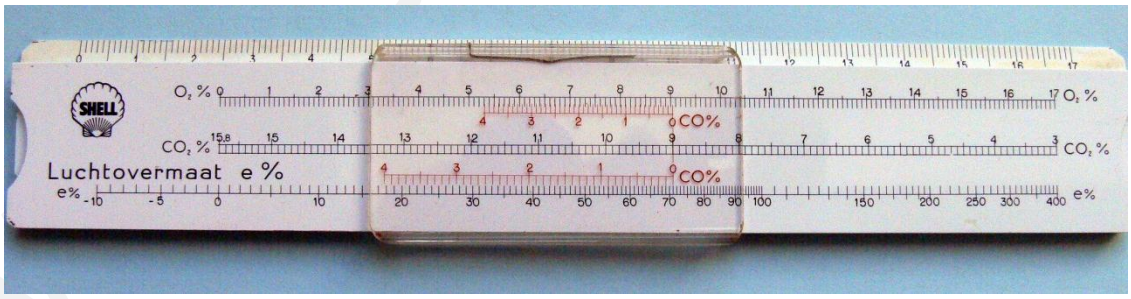


Fig. 6: **SNV Central Heating Efficiency Slide Rule – front face with cursor**

The cursor has a single hairline and two limited range indices for the percentage of carbon monoxide (*CO%*). The top two scales on the stock are linear. The first, with a 0-17 % range, was a scale for oxygen (O_2 *%*). The other, with a 15.8-3 % range, was for carbon dioxide (CO_2 *%*). In contrast, the bottom scale, for the percentage of *Excess Air Pressure* ("*Luchtovermaat e %*"), is logarithmic. When used in conjunction with the cursor, the inspectors could quickly use the scales to find out the relative CO_2, O_2 and CO percentages and the excess air levels in the flue.

Fig. 7: **SNV Central Heating Efficiency Slide Rule – back face with double-sided slide**

In contrast, all the scales on the back of the slide rule are logarithmic. The top scale is the same 15.8-3 % range for the metered CO_2 level but this time drawn as a logarithmic scale (CO_2 *%*). The scale on the slide is for the temperature in degrees Centigrade (*°C* – when reversed, the slide has the "same" scale but this time in degrees Fahrenheit). The bottom two Kcal/kg calorific scales represent: (i) the combustion value of the heat released when the fuel is completely combusted and water vapour condenses in the exhaust gases (H_v – "verbrandingswarmte" or "gross heating power") and (ii) the combustion value of a fuel at which the water vapour does not condense (H_s – "stookwaarde" or "net heat value"). When used in conjunction the *Stack-Loss in %* ("*Schoorsteenverlies in %*") gauge mark on the slide, the inspectors could quickly use the scales to find out the relationship between the temperature of the gasses in the flue, the CO_2 content and any unspent fuel escaping out of the flue.

Apart from *"Modèl Déposé"* on the back face (appears on both the Dutch and French language versions that I have) the slide rule has no clues to suggest the manufacturer. However, the quality and style of its duplex design, the nature of the cursor, the accuracy of the scale markings and the photochemical process (rather than incision) used to apply them is compelling evidence [3] that SNV commissioned the rule from French manufacturer; Graphoplex. The Shell trade mark logo, the "St. Jacob's shell" or Pectens type seashell in the top left-hand corner (see Fig. 6), is further proof of the rule's provenance. Shell's choice of the Pecten as a trade mark goes back to its 1830 roots. In those days the company was importing oriental and exotic seashells that the Victorian's loved to decorate items like trinket boxes [4]. It was only at the end of the 19th century that the name Shell became part the company name and they started to trade in oil.

Fig. 8: **Shell Pecten logo design through the years**

Around 1900 the logo was a flat clam-like shell. But all the subsequent iterations (Shell luckily chose a logo that was easy to refresh/modernise without losing its brand association) have resembled Pectens; a seashell type with a graduated waveform. Thanks in part to the Pecten logo, Shell is now one of the most easily recognised brands worldwide.

The style of the Pecten on the front face of the rule (see Fig. 6) confirms a 1955 to 1961 provenance. However, I also have one example where the Pecten on the accompanying stitched brown leather case is from the earlier 1948 to 1955 period – perhaps an early prototype?

How Was It Used?

Heating oil is a petroleum-derived hydrocarbon. The slide rule is calibrated for a 84.9% Carbon (C), 11.9% Hydrogen (H), 2.6% Sulphur (S) and finally, 0.6% Nitrogen (N) and minor trace elements mix. The calibration could have easily been extended to cover other fuels providing the nitrogen content was equally low. The combustion of any carbon-based fuel is a collection of chemical reactions. By far, the most important is the oxidation of the carbon, hydrogen and sulphur into carbon dioxide, water and sulphur dioxide.

The optimum combustion level is where all the carbon and hydrogen is completely burnt off as any remaining carbon gets converted into dangerous carbon monoxide (CO). Air (in the form of oxygen and nitrogen) is the catalyst for the process. Therefore most central heating systems tend to make sure that an overgenerous flow of air is on hand to stimulate the chemical reaction. For oil based systems this can mean as much as 25 – 50% excess air pressure or a factor of 1.25 to 1.50. Perhaps unexpectedly, an overgenerous dose of air does not necessarily improve the combustion process. An excess of air is not necessarily detrimental to oxidation process but it can negatively reduce the temperature at which the oil is being burnt. This will raise the amount of soot in the exhaust gasses coming out of the flue. Therefore the secret to economical combustion is to ensure that the fuel is completely burnt – too little or too much air quickly reduces the efficiency of the combustion process.

With the system running but sometimes to the alarmed looks of its proud owner, the inspectors would start their assessment by drilling a small 7 mm hole in the metal flue pipe of the central heating unit. To ease the owner's fears, the inspectors would show that there was a constant slight pressure drop in the flue and this meant that extra air was being sucked in rather than exhaust gasses being pushed out. They did this by holding a cigarette lighter by the hole to show that when lit, the flame got sucked into the flue [1]. Through this small hole the inspectors would use their metering equipment to record the:

- temperature
- amount of CO_2 (n.b. by changing the fluid, the same indicator could also sample for O_2)
- amount of soot (to check if too much excess air was present at combustion)

present in the flue pipe.

Fig 9: **thermometer to measure the temperature of the flue gasses**

Fig. 10: **metal sampling tube with built-in smoke filter and a rubber bulb to hand-pump a gas sample**

After taking their measurements, the inspectors would seal the hole with a small self-tapping screw. Now armed with just these few readings, the inspectors would first use the front of the slide rule to calculate the relative levels of CO_2, O_2, CO and the % of excess air present. The scales are clever representations of two complex combustion formulas [5]:

$$a = a\circ - (1 - \frac{79}{4200} a\circ)\beta - \frac{a\circ}{21}\omega$$

and

$$21\frac{e}{100}\frac{V1}{Vg} = \frac{a\circ}{a+\beta}(\omega - \frac{\beta}{2})$$

Where: $a\circ$ = CO_2
β = CO
ω = O_2
V1 = the volume of air in nm^3/kg
Vg = the volume exhaust gasses in nm^3/kg
for combustion where there is no excess air present.

Normally when burning home heating oil, virtually no CO is given off. Hence, the relationship between the CO_2 and the O_2 levels is key. The adjustment needed for the small percentage of CO present can easily be made through the two CO% indices on the cursor. So the inspectors could determine the combustion levels for their assessment with one simple setting:

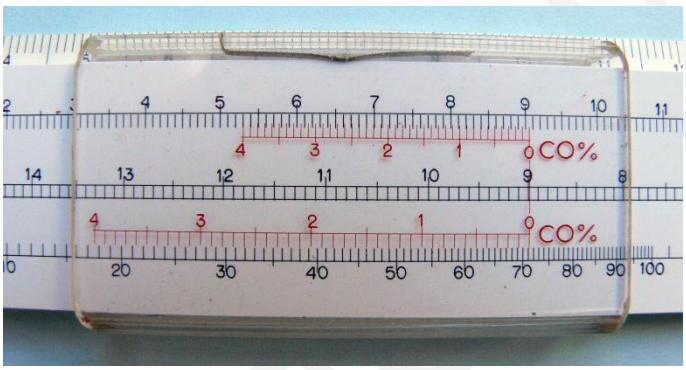


Fig. 11: **example setting of how inspectors checked combustion levels and % reduced/excess air**

The example is for a metered CO_2 % value of "9". Using an assumed CO% value of "1", the upper *CO%* index gives a reading of 8.1% for O_2 and lower *CO%* index a reading of 53% excess air. The latter could be compared to the level of soot found in the flue. Clearly if any two values were known, for example the CO% or O_2 %, the third could be quickly calculated and if all three were known (would require extra measurements); any less than optimum inconsistency in the readings would be exposed.

The inspectors would now use the scales on the back face to compare the temperature in the flue, the CO_2 % and the calorific value of any unspent fuel escaping through the flue. The scales are clever logarithmic representations of the tables developed by a French mineralogist, Ernest-François Mallard (1833-1894), and a French chemist, Henry Louis Le Chatelier (1850-1936).

Fig. 12: **example setting of how inspectors checked calorific combustion values**

A possible metered flue temperature reading of “250” °C on the slide is set against the same metered CO_2 % value of “9”. From this one setting it was possible, assuming ideal combustion (i.e. no CO given off), to use the gauge mark to determine the two calorific combustion levels. Including the handy gauge mark meant a duplex or reversible cursor was not needed. In the example, the loss through the flue of heat released (H_v) is just over “20%” and for uncondensed water vapour (H_s) just over “15%”.

With these calorific values the inspectors could easily finish off their assessment as they all knew that the accepted net fuel return for any installation was 80% - i.e. any installation with a net calorific heat value (H_s) of 20% or lower, was clearly working according to the industry norm. In the example shown, the installation has an excellent calorific heat value (H_s) of just over 15%. Such a result would clearly have been beating the accepted efficiency norm of the 1960’s. Decades later, central hearing systems were being fitted with heat-exchangers. This raised the efficiency norm from 80% to at least 90%.

Other Shell Versions

The specially commissioned SNV slide rule was clearly based on an earlier circular cardboard version from the 1950’s. It was probably developed for in-house use by the established furnace/boiler experts before the team of Shell Heating Oil Inspectors was formed and the more impressive efficiency slide rule was developed [1]. The address in The Hague (Wassenaarseweg 80) for SNV is a good date indicator as their head office moved from The Hague to Rotterdam in the early 1960’s.

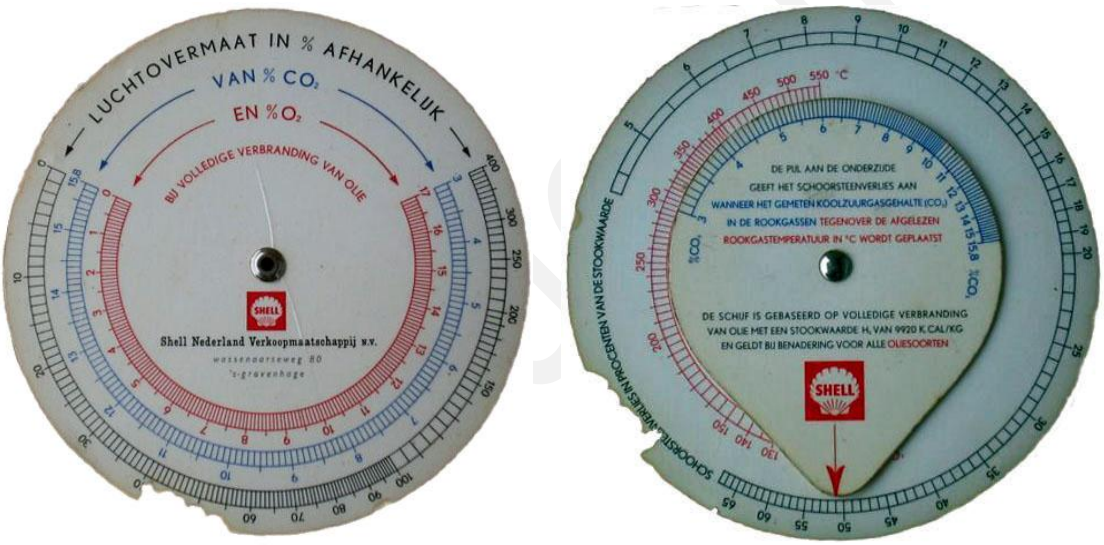


Fig. 13: **circular forerunner to the Central Heating Efficiency Slide Rule**

There is no evidence of any inter-company cooperation but decades after the SNV development, two neighbouring Shell companies, in West Germany and in the UK, brought out similar slide rules.

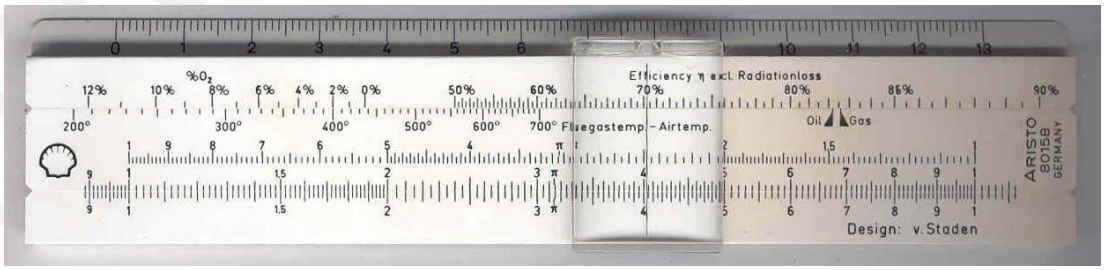
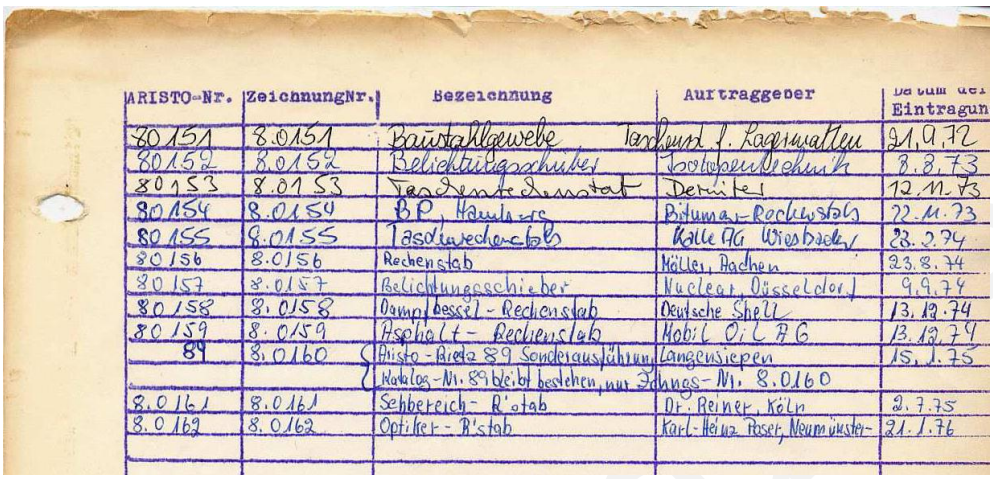


Fig. 14: **front face of the Aristo 80158 pocket slide rule for oil and gas-fired boilers**

This single-sided (just instructions, in English, printed on the back) solid frame plastic pocket slide rule (15.5 x 3.2 x 0.5 mm) is part of the Aristo “Sonderrechenstab” or specially commissioned series of slide rules [6]. As signified by the Pecten trade mark logo on the left-hand side of the slide, Aristo made the model 80158 for Shell. However, this time it was Shell Germany, *Deutsche Shell AG*, that commissioned this special “Dampfkessel-Rechenstab” – a slide rule for oil or gas-fired boilers. Its name and the wide 200 - 700 °C range of the temperature scale strongly suggests that this Shell slide rule was primarily for commercial rather than household boilers.



ARISTO-Nr.	ZeichnungNr.	Bezeichnung	Auftraggeber	Datum der Eintragung
80151	8.0151	Baustahlgewebe Tischlund f. Lagerwaffen		21.9.72
80152	8.0152	Belichtungsschieber	Isolierungstechnik	8.8.73
80153	8.0153	Taschenrechenstab	Demiter	12.11.73
80154	8.0154	BP Hamburg	Bitumar-Rechenstab	22.11.73
80155	8.0155	Taschenrechenstab	Kalle AG Wiesbaden	23.2.74
80156	8.0156	Rechenstab	Müller, Aachen	23.8.74
80157	8.0157	Belichtungsschieber	Nuclear, Düsseldorf	9.9.74
80158	8.0158	Dampfkessel-Rechenstab	Deutsche Shell	13.12.74
80159	8.0159	Asphalt-Rechenstab	Mobil Oil AG	13.12.74
89	8.0160	Aristo-Rietz 89 Sonderausführung, Modelles-Nr. 89 bleibt bestehen, nur Zeichnungs-Nr. 8.0160	Langensiepen	15.1.75
8.0161	8.0161	Sehbereich-R'stab	Dr. Reiner, Köln	2.7.75
8.0162	8.0162	Optiker-R'stab	Karl-Heinz Faser, Neumünster	21.1.76

Fig 15: **extract from the Aristo “Register of Special Slide Rules”**

As shown in the Aristo register, the Shell commission dates from December 13th 1974 [6]. But so far, despite writing repeatedly to Deutsche Shell AG, I have been unable to find out any more about this rule or its designer; “v. Staden”. It was most likely a promotional slide rule for prospects or existing commercial customers. Unfortunately nothing more can be found in the Aristo archives. So, for example, the number of 80158’s made is unknown but it is likely to have been relatively few [7].

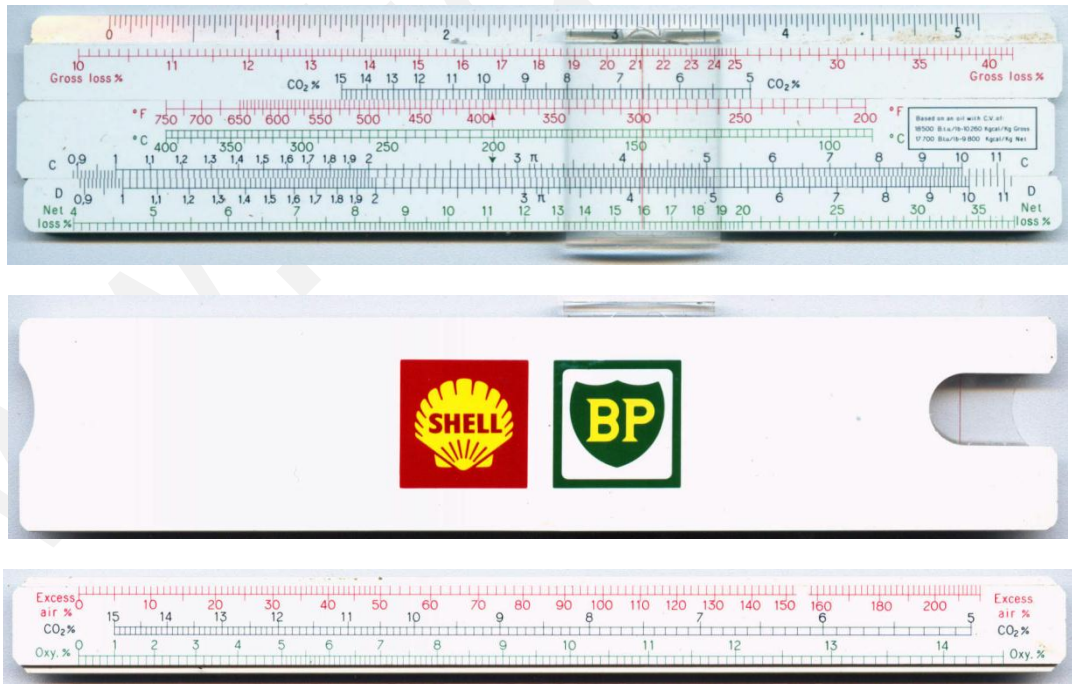


Fig. 16: **front and back faces of the Shell-Mex/BP Stack-Loss pocket slide rule**

As represented by the twin Shell and British Petroleum (BP) trademark logo’s, this solid frame plastic pocket slide rule (15.5 x 3.2 x 0.5 mm) is from the Shell-Mex/BP (SMBP) Ltd joint venture (JV). Set

up in 1931, the JV was limited to the joint marketing and distribution operations in the British Isles. 60% of the JV shares were owned by Shell (the “Mex” suffix is a throw back to the importance of Mexico in those days) leaving a minority 40% share for BP. The JV was broken up in 1971. From the style of the Shell Pecten (see Fig. 8 - the BP logo was not modernised as often as the Pecten) it dates from the 1961 to 1971 period and was most likely a promotional slide rule for JV prospects.

Once again the photochemical process used to apply the scales is a tell-tale sign that it was made by Graphoplex. An identical BP-only version of the rule (not shown) does have the Graphoplex trade mark logo and *“BREVET S.G.D.G. MADE IN FRANCE”* stamped in the plastic. For the follow-on SMBP version, the distinctive cursor and CO% indices have been replaced with a standard single-hairline plastic cursor. However, apart from adding basic C and D scales, all the special scales, albeit with slightly modified ranges, have been “replicated” from the SNV version. But the esoteric SNV overall design has gone and the emphasis has shifted. This SMBP version has "Stack-Loss" promoted to the front of the rule and the combustion levels relegated to the back. A move in the late 1960’s to more efficient central hearing systems (i.e. with built-in heat-exchangers) is probably behind the small adjustment to the range of some scales. Also by 1970, stack-loss rather than combustion levels had probably become the more telling indicator for efficient running. It is uncertain if the rule was specially commissioned by SMBP or that Graphoplex had decided to add a Stack-Loss pocket slide rule to its product line. Adding C and D scales for general calculation purposes and the existence of non-Shell branded versions adds credibility to the idea that it had become a standard Graphoplex product by now.

Other Central Heating Efficiency Rules

The boiler and heating branch is blessed with a wealth of colourful slide charts for pumps, nozzles, etc and a few interesting slide rules. For example, there is the *“Domestic Central Heating Calculator”* from the UK manufacturer Mear. Most major oil companies and heating suppliers also had promotional/advertising slide charts, etc. However, apart from the Shell versions, there is only one slide rule that has any degree of similarity with the SNV Central Heating Efficiency Slide Rule. It is the Faber-Castell (F-C) model 57/69 solid frame plastic (298 x 40 x5.5 mm) single sided (just instructions on the back) slide rule. It dates from the 1950’s and, ironically, it has Dutch connections.

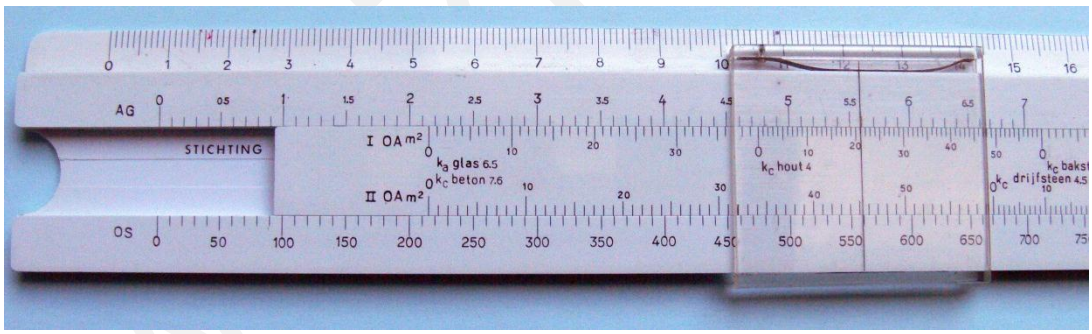


Fig. 17: **Faber-Castell 57/69 from 1951 – left-hand front face with scale annotations and cursor**

Like the Aritso example, the F-C 57/69 was not a standard product but came from their commissioned series. But in the case of F-C, such rules do not feature in any of their catalogues, etc [8]. F-C made the rule for the “*Stichting Vakcursus Verwarmingsartikelen En Kookapparatenhandel”* and according to their design. This Dutch trade foundation, based in Leiden and operating for the industry as a whole, organised training courses on heating systems and cookers. The rule was part of the course material and its design was so innovative it was granted a Dutch patent (No. 81186) in 1956.

Like the SNV Central Heating Efficiency Slide Rule, the F-C 57/69 was designed to help improve the efficiency of central heating systems. However, unlike its Shell “twin”, the F-C rule ingeniously helped calculate the optimum capacity needed for an efficient central heating system. Whereas its later SNV counterpart helped insure that the installed capacity was functioning correctly and efficiently.

Did It (Really) Generate Profit For Shell?

The free assessments offered by Shell proved a great hit with consumers in Holland. Without the specially developed slide rule it would probably have proved too cost-prohibitive or too time-consuming for SNV to commit to a country-wide programme of household/SOHO assessments. From the monthly records maintained by the inspectors, it is possible to gauge how much new business the assessments brought in. However, the success rate in these statistics is partly distorted by the latent potential for switching to oil. For example, did a particular area of the country have a high proportion of old Remeha coke-fired furnaces in need of replacement? It was possible to convert such furnaces to oil, but most opted for full replacement. In such areas, SNV captured as much as 50 per cent of the new oil-based market. In fact as soon as SNV had signed up a household/SOHO for home heating oil, a square cement "filling point" with a Shell Pecten lid was placed prominently in the garden. This told the competition that, once again, the new business had gone to Shell [1].

So by the end of the 1960's the country-wide market share for home heating oil that Shell had captured in The Netherlands was **at least 35 per cent**. If judged by accepted marketing or media success rates, anyone with a 35^{+}% market share clearly dominated the consumer market and was the market leader. However, despite finding other versions, some with scale annotations in French and in English, there is no evidence that the marketing campaign behind the SNV Central Heating Efficiency Slide Rule was adopted or used by Shell in any other countries. Despite being seen as a "global company", Shell business units of the day fiercely protected their home country independence and inter-company fiercely competitive "national pride" prevailed. For example, Shell did not create a single "Shell Europe" multi-country organisation with a single management structure until the late 1990's.

So tragically the potential of the SNV Central Heating Efficiency Slide Rule to generate extra profits as market leader was not repeated by Shell outside The Netherlands. No records were kept (or have since been lost) but it is thought that **no more than 50 of these innovatively designed and profit-generating speciality slide rules were ever made.**

Epilogue

Ironically since I started writing this paper, *Shell Nederland* has decided to sell off their household oil and lubricants delivery business [9]. In July 2008 they sold the business to the Breda-based *Catom Petroleum Distribution Management.* Perhaps the SNV Central Heating Efficiency Slide Rule finally lost its magic?

Acknowledgements

The following people (listed alphabetically by surname) filled in many of the gaps and "missing answers" left by my initial research:

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- **J. Kruisdijk** for donating his SNV Central Heating Efficiency slide rule with accompanying instructions and the book *"Volautomatisch Olie Stoken"* to my collection.
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- fellow collectors **Rod Lovett** and **Colin Barnes** for respectively the images of the Aristo 80158 and the Graphoplex/SMBP Stack-Loss slide rules

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