Energy-sources

Varios energy sources can be applied to produce a seismic signal.

a.) Dynamit, either in cartridges of 5, 10 or 20kg or cord of 50/100m length at 80, 100 or 200grain/m (5g / 6.5gr / 13gr/m)

b.) compressed air – Airgun / Watergun

c.) explosive gasmixture – Aqua Puls / sleeve exploder

d.) gas-discharge between electrodes – Sparker

e.) Vibration – Vibrators
· (graph 1)

In the past, the airgun-system proofed to be the most efficient energy tool, if the bubble pulse can be eliminated and the synchronisation problems settled.

This airguns are mainly used in forms of towed arrays.

How does an airgun works?

The airgun consists of

① the chamber - which keeps the compressed air to be discharged to the water

② the piston - which locks the chamber and through which the air is transported to the chamber

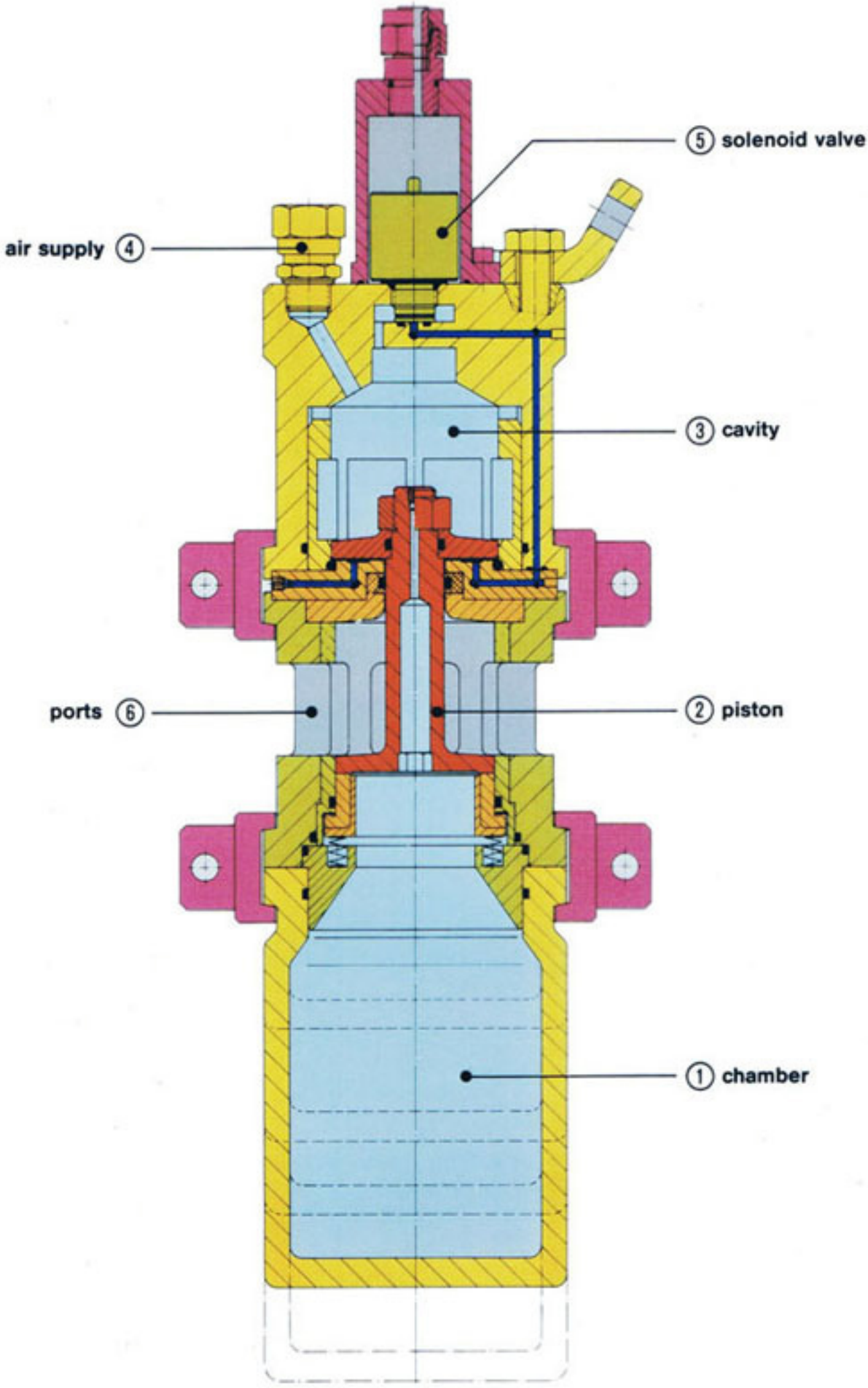
③ the cavity - which keeps the space for the piston to move up-wards.

④ the air supply - the air entrance from the compressor to the cavity

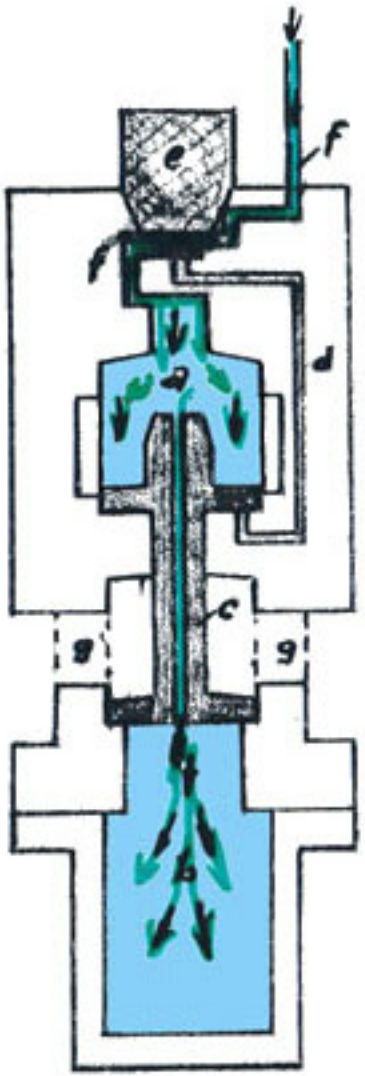
⑤ the solenoid valve - which controlles the moving of the piston and therwith the firing moment.

⑥ the ports - 4 ports through which the compressed air is discharged to the water.

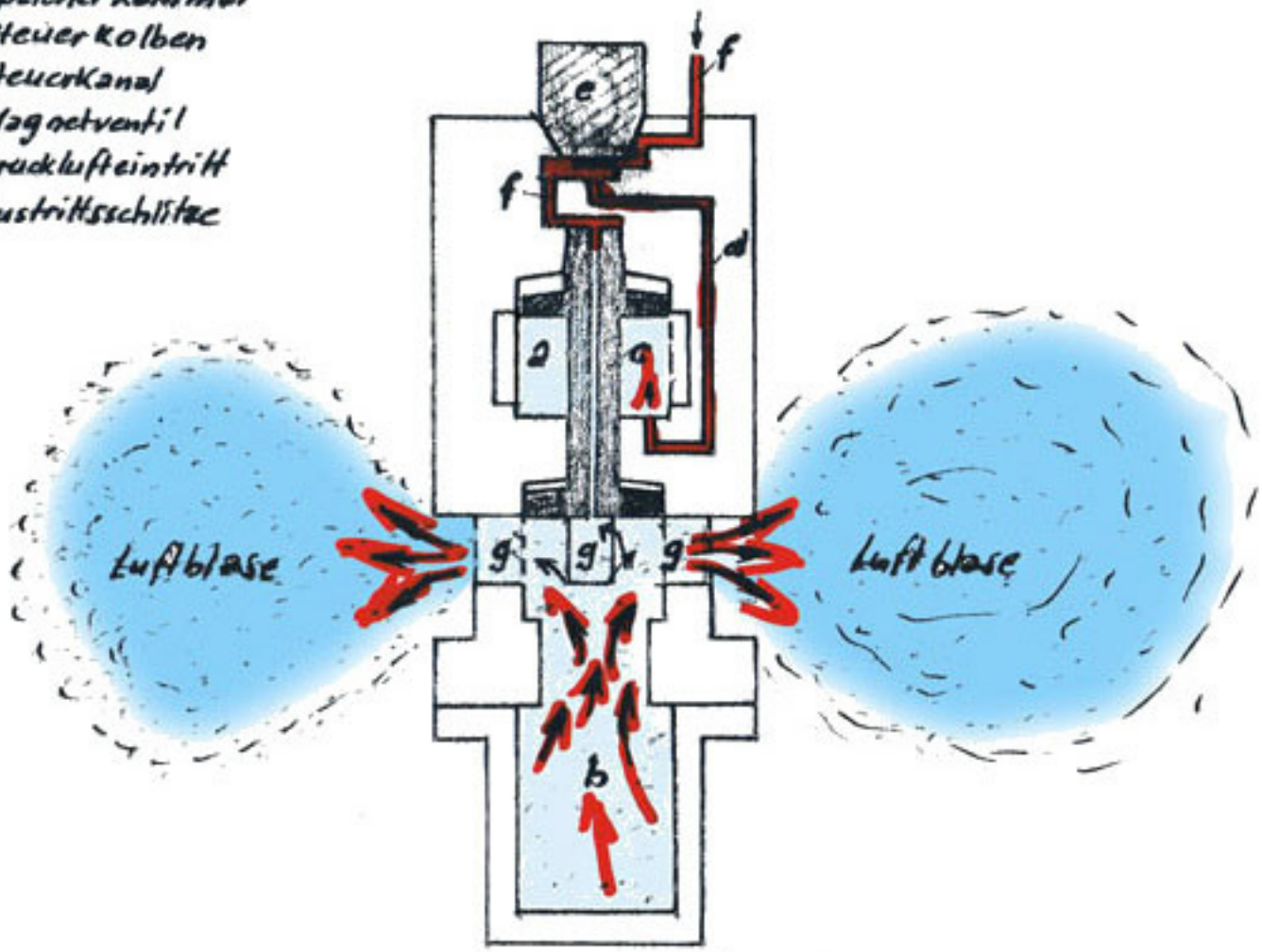
PRAKLA-SEISMOS Airgun



a = Steuerkammer
b = Speicherkammer
c = Steuerkolben
d = Steuerkanal
e = Magnetventil
f = Druckluft eintritt
g = Austrittsschlitze



Ladezustand



Entladungszustand

Schnittbild einer Luftkanone

Sequence of operation:

Through the air supply the air enters the cavity and presses the piston down to close the chamber

Through a small pipe in the piston's shaft the air passes to the chamber.

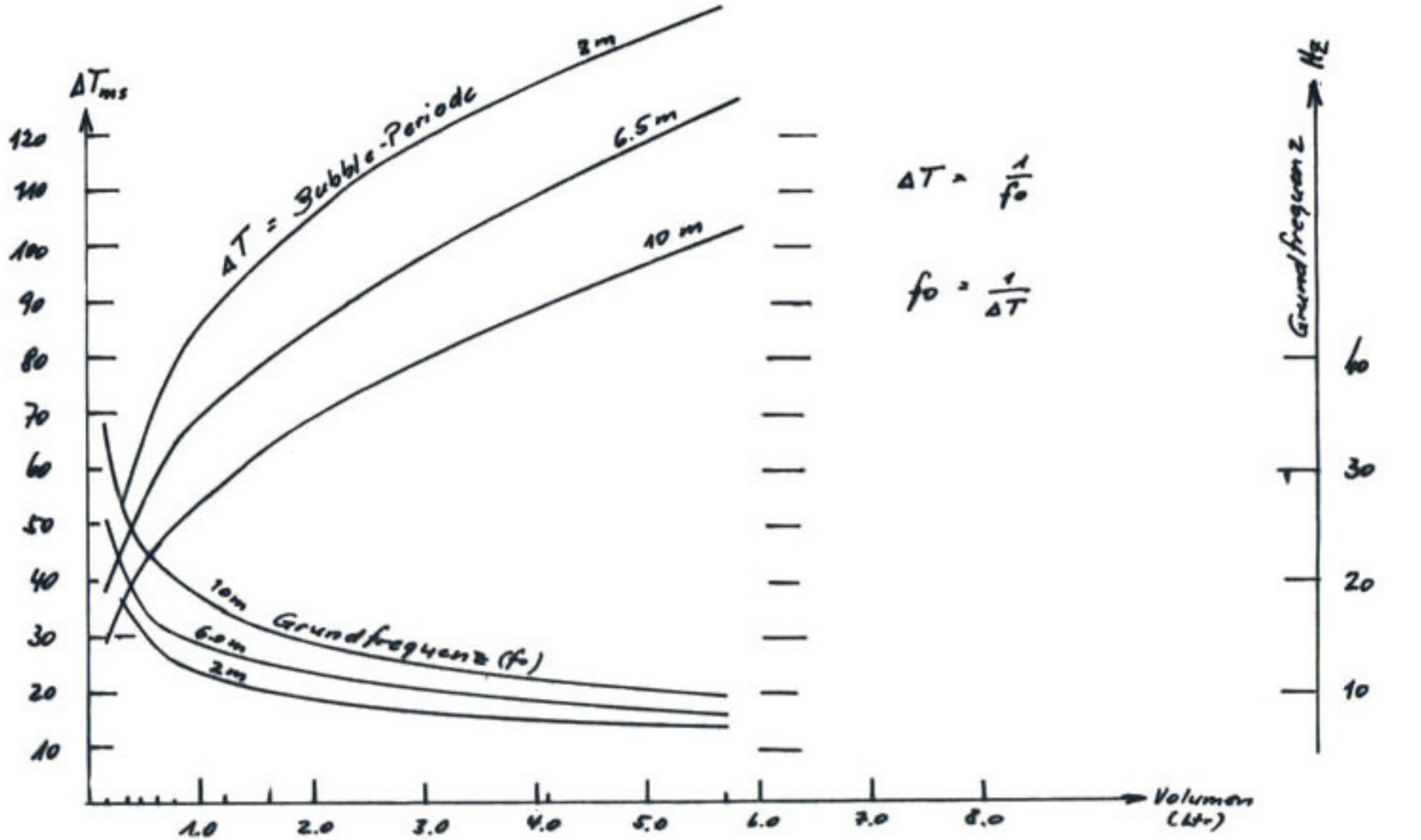
The piston will be kept in "closed position" because the top diameter is larger than the one below.

This inbalance will be kept, until the solenoid valve will open a by-pass, which end underneath the topplate of the piston

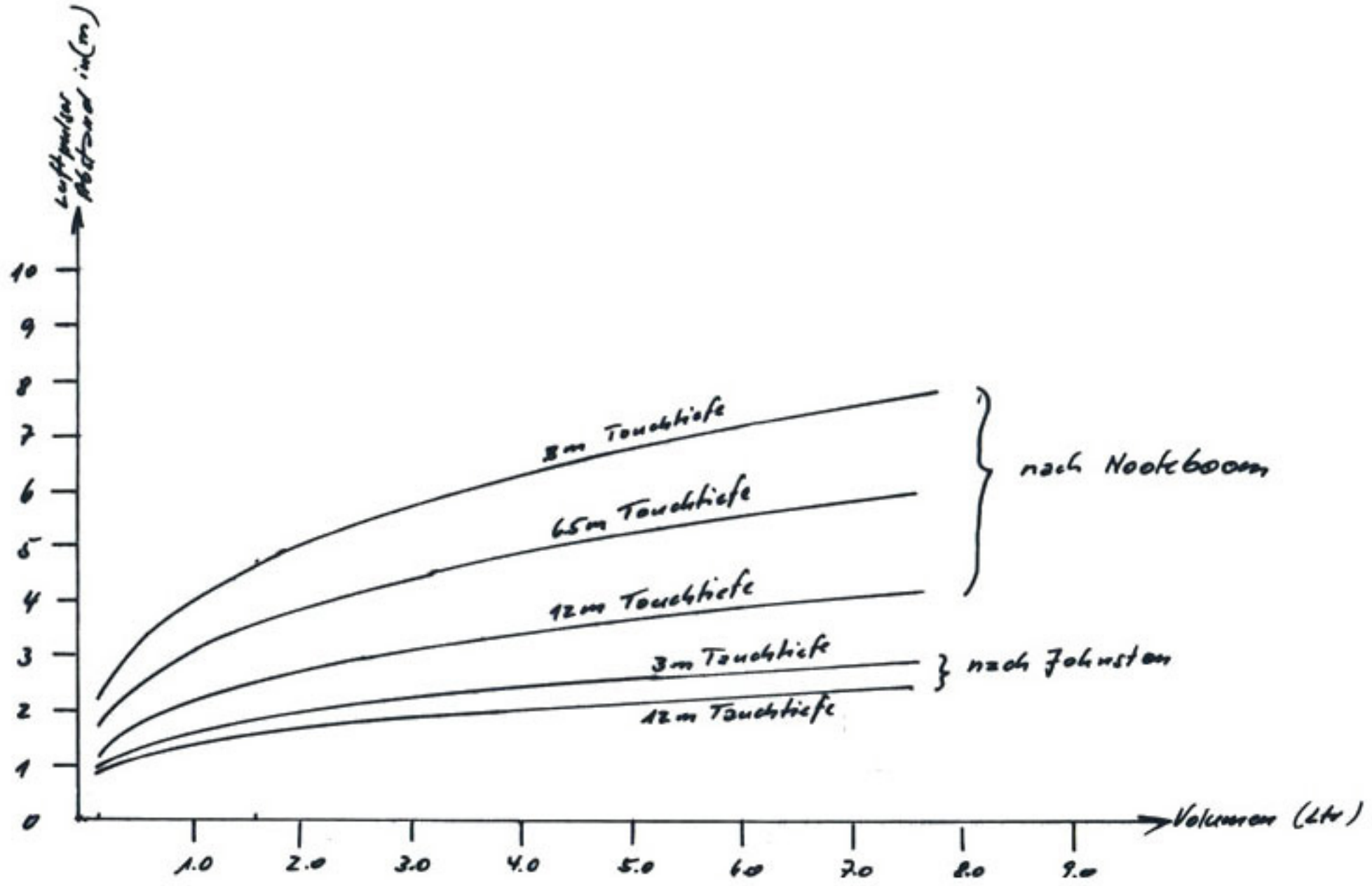
If this happenes, the piston will move up into the CAVITY and opens the ports - the air from the chamber will discharge immediately into the water - the first pulse is created.
However, this air-bubble is oscilating until it reaches the surface.
The bubble periode is depending of the air volume discharged and is moving towards the surface with 0,95 m/sec creating the unwanted Bubbles.

Signals of Airguns

Each airgun-volume is responsible for an exact frequency of only 1 Hz bandwidth.



Bubble-Periode und Grundfrequenzen
in Abhängigkeit zur Tauchtiefe



Mindest-Abstand für "interacting-frac" Operation

Aus der Bubble-Periode ΔT läßt sich auf die Grundfrequenz (Hz) einer Kanone als auch eines Arrays schließen.

$$fo = \frac{1}{\Delta T_{sec}}$$

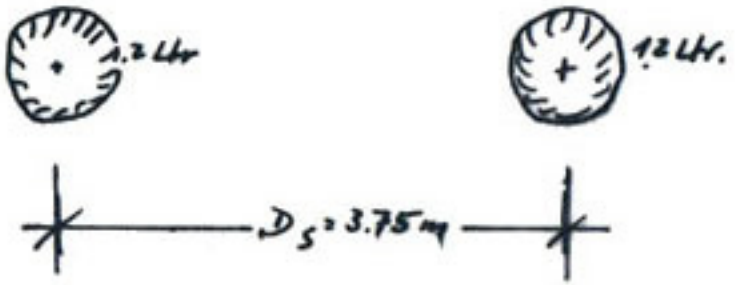
fo aus Fig. 5-18

Volum.	Array-T d	P-P Δt	B-Periode ΔT	Grundfreqq. fo	Power output bar×m
0.16 Ltr	6.5m	8.6ms	39ms	25 Hz	0.7
0.33 Ltr	6.8m	9.0ms	45ms	22 Hz	1.4
0.45 Ltr	6.0m	8.0ms	51ms	19.5Hz	1.7
0.6 Ltr	7.5m	10.0ms	60ms	16.5Hz	2.1
0.75 Ltr	6.0m	8.0ms	66ms	15.0Hz	2.4
1.0 Ltr	6.0m	8.0ms	71ms	14.0Hz	2.9
1.2 Ltr	7.8m	10.5ms	76ms	13.0Hz	3.3
1.6 Ltr	7.1m	9.5ms	79ms	12.5Hz	3.5
2.0 Ltr	6.4m	8.5ms	85ms	11.7Hz	3.8
2.3 Ltr	7.1m	9.5ms	90ms	11.0Hz	3.9
2.5 Ltr	6.3m	8.4ms	91ms	11.0Hz	4.0
3.7 Ltr	6.8m	9.0ms	101ms	10 Hz	5.1
4.1 Ltr	7.0m	7.6ms	110ms	9 Hz	5.4
5.7 Ltr	6.0m	8.0ms	125ms	8 Hz	7.7

Mit Hilfe von ΔT läßt sich ein Array "tunen" durch Kombination verschiedener Volumen.

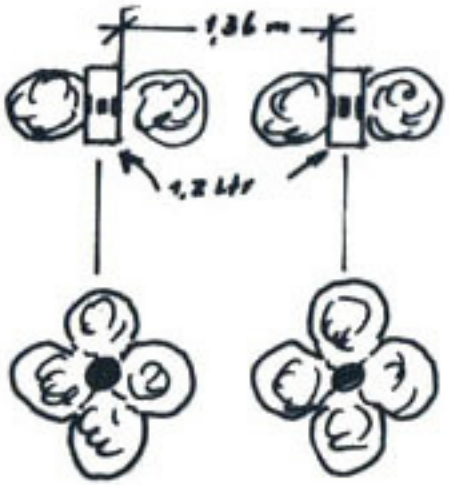
Mindestabstand nach Nooteboom: $D_s \geq 5.1 \frac{(P_e V_c)^{1/3}}{P_0^{1/3}}$

D_s = Mindestabstand (inch)
P_e = Speicherdruck (psi)
V_c = größeres zweier benachbarter Volumen (cu. inch)
P_0 = hydrostatischer Druck (psi)



Mindestabstand nach Johnston: $D_j \geq 1.256\ m \sqrt[3]{V_c} + dg$

D_j = Mindestabstand (m)
V_c = größtes zweier benachbarter Volumen (Ltr)
dg = Durchmesser des Luftpulsers



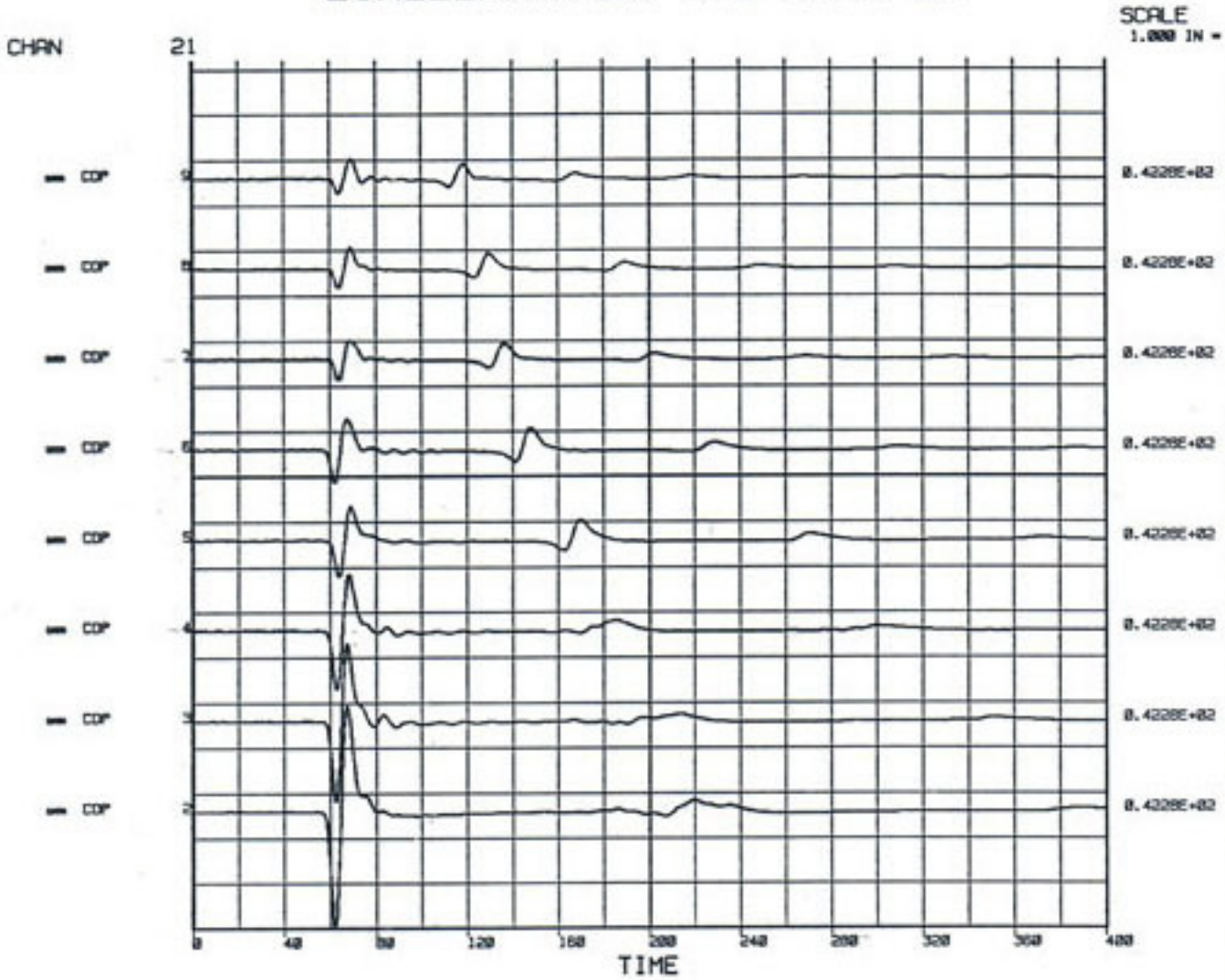
Nach Johnston entsteht vor jedem Auslaßschlitz eine separate Luftblase, deren Durchmesser sich wie folgt berechnen läßt:

$$d_{3max} = \left[\frac{6}{\pi}\left(\frac{P_c}{P_{b\,min}}\right)^{\frac{1}{k}}\right]^{1/3}\left(\frac{V_c}{N_p}\right)^{1/3}$$

FARFIELD SIGNATURE OF "B 23/31" AIRGUN ARRAY (W82.S.W.)

AIRGUN ARRAY TEST BY SV SOLER IN MEDETERANIEN WATERS OFF TRAPANI.ITALY. MAY 84

EINZELKANONEN UND GRUPPEN

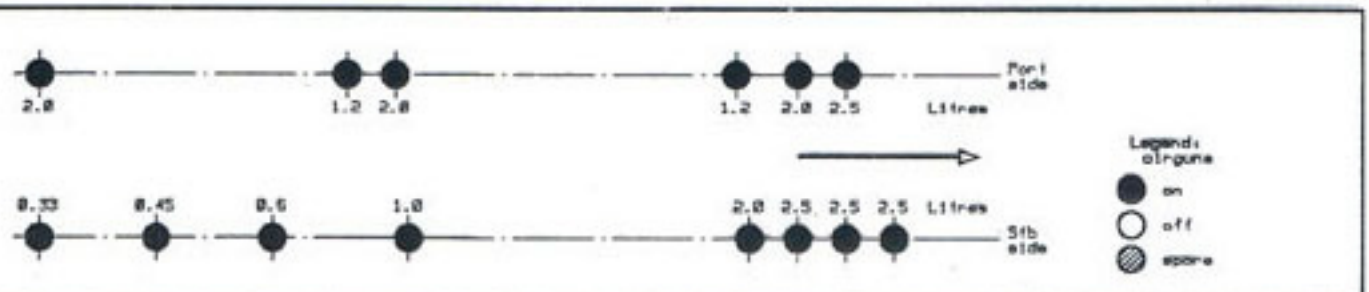


INSTRUMENT : DFS - V REEL : 103	ARRAY CODE : B23/31 ARRAY DEPTH : 3.00 MTR. HYDR. DEPTH : 70.00 MTR. (BELOW AIRGUN)	TOTAL VOLUME : 22.78 LTR SINGLE GUNS AND GROUPS	DSB 3.0	
LC HZ/DB : OUT HC HZ/DB : 128/18	HYDR. SENS. : 0.6 V/BAR		FIG. 4.2	PRAKLA-SEISMOS
SAMPLE RATE : 0.5 MS REC. LENGTH : 1.024 SEC	RECORDED : 30.05.84 PROCESSED : 00.00.84	PRESSURE : 150 BAR T 0 DELAY : 10 MSEC		

FARFIELD SIGNATURE OF "B 23/35" AIRGUN ARRAY (W82.S.W.)

AIRGUN ARRAY TEST BY SV SOLEA IN MEDETERRANIEN WATERS OFF TRAPANI.ITALY. MAY 84

EINZELKANONEN UND GRUPPEN



INSTRUMENT : DFS - V REEL : 102	ARRAY CODE : B23/35 ARRAY DEPTH : 6.00 MTR. HYDR. DEPTH :67.00 MTR. (BELOW AIRGUN)	TOTAL VOLUME : 22.78 LTR SINGLE GUNS AND GROUPS	030 6.8	
LC HZ/DB : OUT HC HZ/DB : 128/18	HYDR. SENS. : 0.6 V/BAR		FIG. 4	
SAMPLE RATE : 0.5 MS REC. LENGTH : 1.024 SEC	RECORDED : 30.05.84 PROCESSED : 23.07.84	PRESSURE : 150 BAR T 0 DELAY : 10 MSEC		

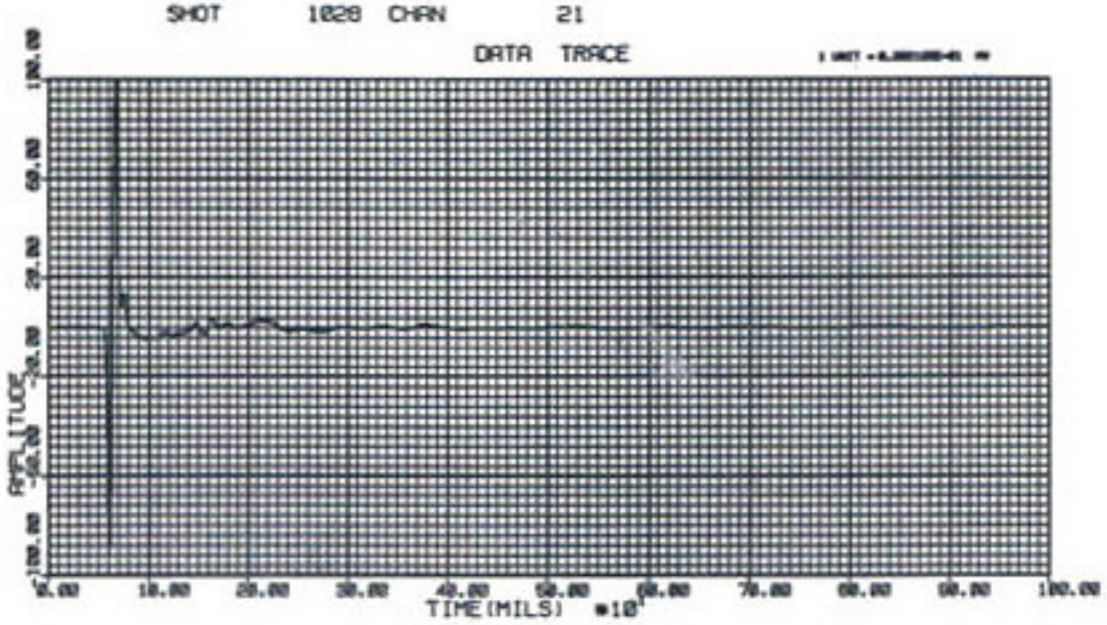
FARFIELD SIGNATURE OF "B 23/30" AIRGUN ARRAY (W82.S.W.)

AIRGUN ARRAY TEST BY SV SOLEA IN MEDETERANIEN WATERS OFF TRAPANI.ITALY. MAY 84

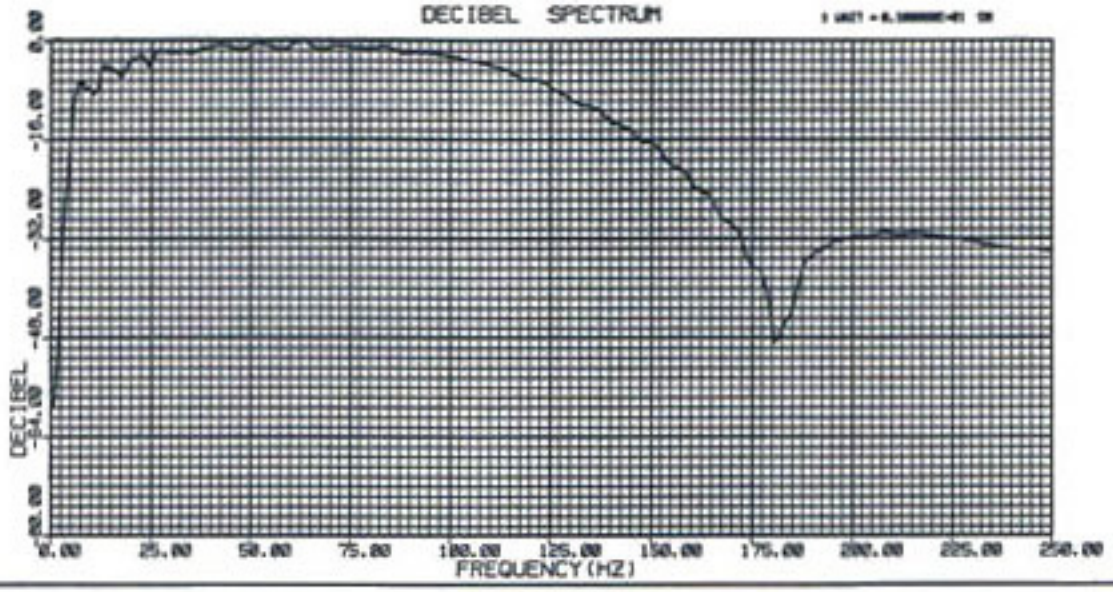
SPECTRUM ANALYSIS

SHOT 1028 CHAN 21

DATA TRACE



DECIBEL SPECTRUM

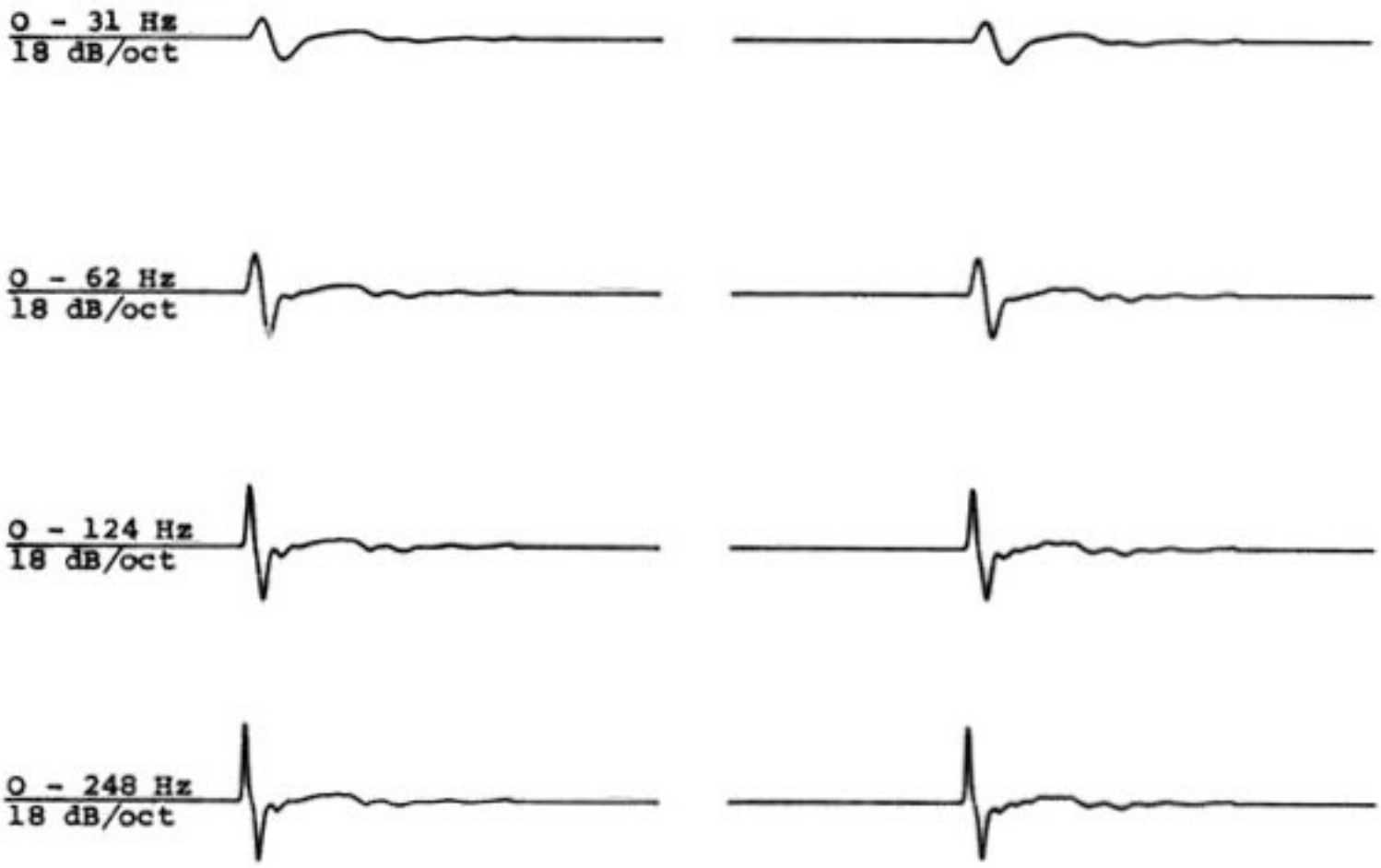


INSTRUMENT	: DFS - V	ARRAY CODE	: B23/30	TOTAL VOLUME	: 22.78 LTR	DT: 4.0	
REEL	: 101	ARRAY DEPTH	: 4.00 MTR.				
REC. NO.	: 1028	HYDR. DEPTH	: 68.00 MTR.	AMPLITUDE PR	: 30.2 BAR/ M	FIG. 1	
CHANNEL NO.	: 21	(BELOW AIRGUN)					
LC HZ/DB	: OUT	HYDR. SENS.	: 0.67 V/BAR	RATIO PR/PB	: 24 / 1		
HC HZ/DB	: 120/18						
SAMPLE RATE	: 0.5 MS	RECORDED	: 30.05.84	PRESSURE	: 150 BAR		
REC. LENGTH	: 1.024 SEC	PROCESSED	: 13.08.84	T 0 DELAY	: 10 MSEC		

U"-Array at 8 m depth - recorded through a DFS IV

vertical scale: 1 mm = 2 bar.m -
based on a Kistler Hydrophone Type 4041A10/No. 71114

filter setting:

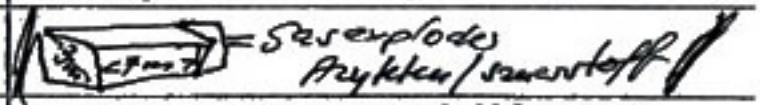
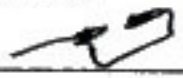


full "u"-array
at 150 kp/cm^2 = 2,150 psi

full "u"-array

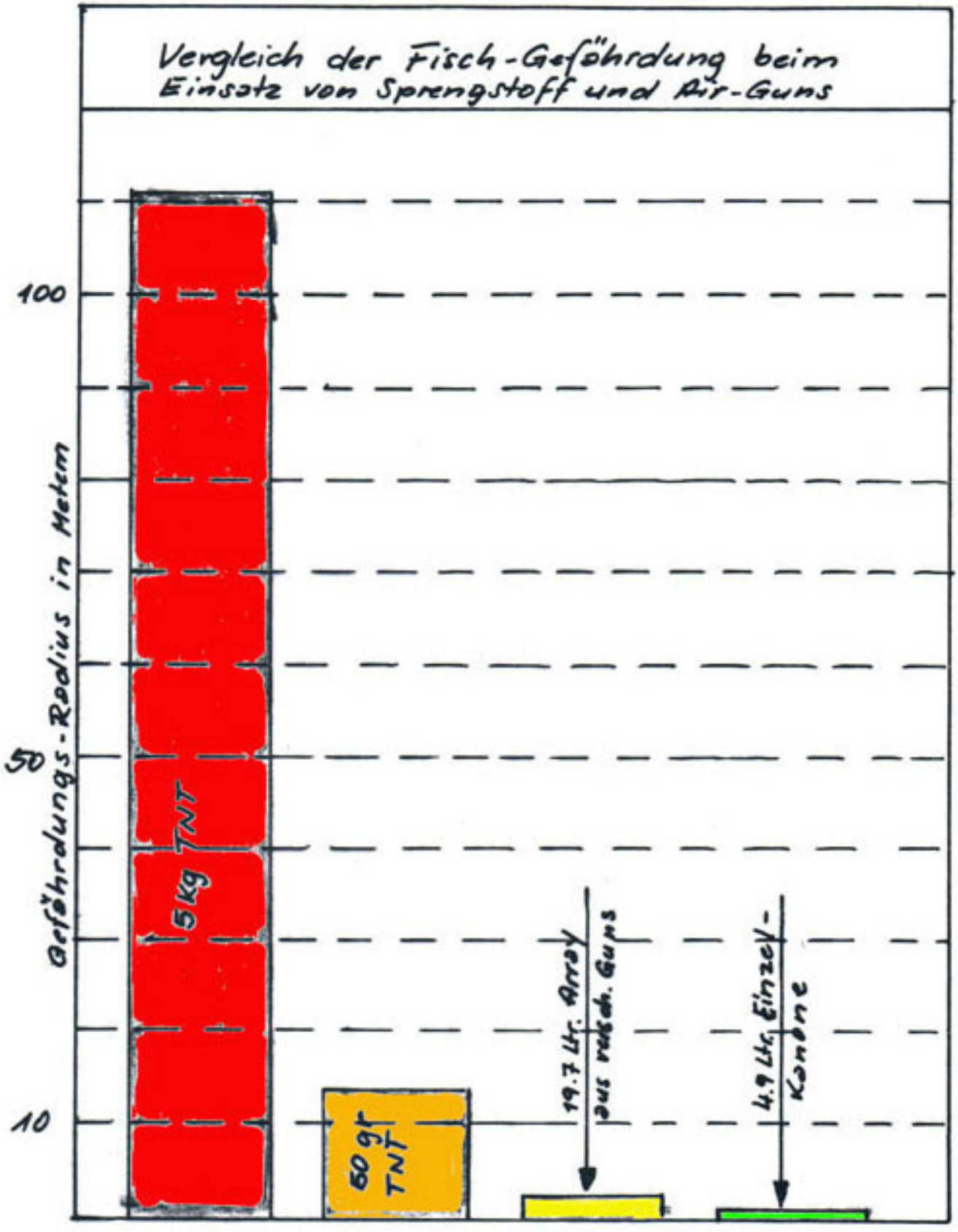
SOME COMMON MARINE SOURCES

Aqua-Pulse 

Name	Energy Source	No. of Units	Stored Energy per Unit kJ	Very approx. and without ghost		Comments
				Efficiency %	Peak-Peak bar.m	
Air-gun	Compressed Air	10 - 15	1000 (1200 cu in)	1	10 - 15	Bubble pulse troublesome. Synchronisation problems.
Maxi-pulse	Solid Explosive	1 x 230 g	1000	1 - 10	6 - 20	Seismic amplitude and pulse shape depends critically on the DEBUBBLING. Shot repetition rate may be too low?
Sleeve-exploder	Propane-Oxygen Mixture	4 - 8	100	3	4 - 8	 Sea explode Propan/Sauerstoff
Flexotir	Solid Explosive	2 x 50 g	450	1 - 2	2 - 5	Solid steel cage reduces bubble pulse amplitudes. Shot repetition rate too low?
Vaporchoc	High Pressure Steam	1 or 2	1300	$\ll 1$	2 - 5	Main seismic pulse is due to collapse of the steam bubble. Total signal is non-minimum phase due to initial release of the steam.
Flexichoc	Mechanically Created Bubble	1 or 2?	50	5	2 - 4	Essentially no fore-runner to main bubble pulse. Mechanical oscillations produce several later pulses.
Water Gun 	Compressed Air	1 or 2	30?	5	4 - 8	Piston drives 4 slugs of water. Major pulse is due to bubble collapse. Insufficient low frequency?
Sparker 	Electric Spark	3 - 30 electrodes	25	$\ll 1$	1 - 2	Source array needs careful design. Short pulse gives good resolution. Penetration of 1 - 2 s?
Seismovac	Mechanically Created Bubble	1 or 2?	7	50?	1 - 2	Insufficient power. Good pulse shape?

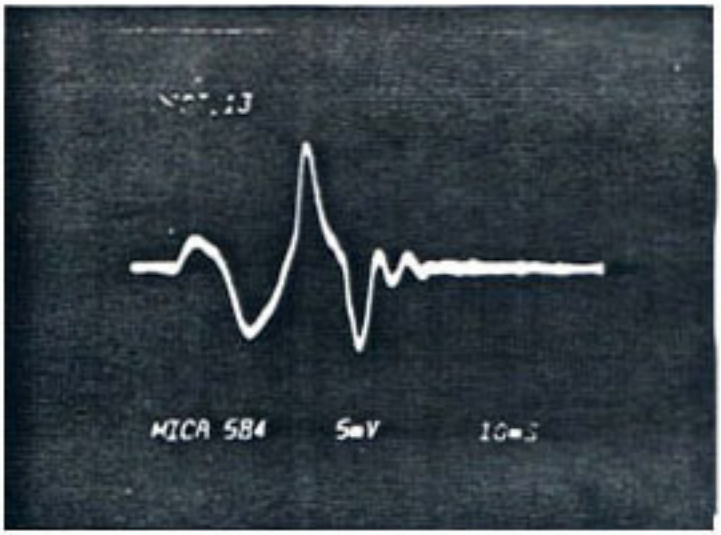
Less Common Sources are VIBROSEIS (mechanical vibrator), DINOSEIS (contained Propane/O_2 explosive), SOSIE (coded sequence of many 'pops'), Boomer (low power, high frequency).

PNSO'B/jm
12th November 1975

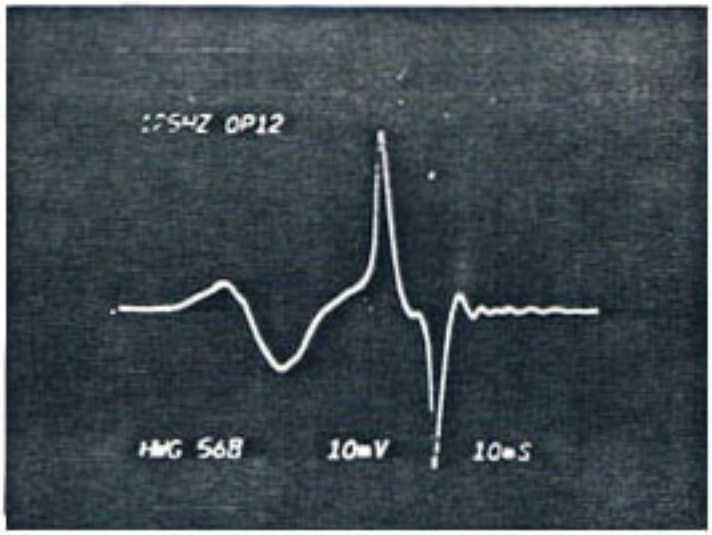


Vergleiche wurden von BOLT ermittelt.

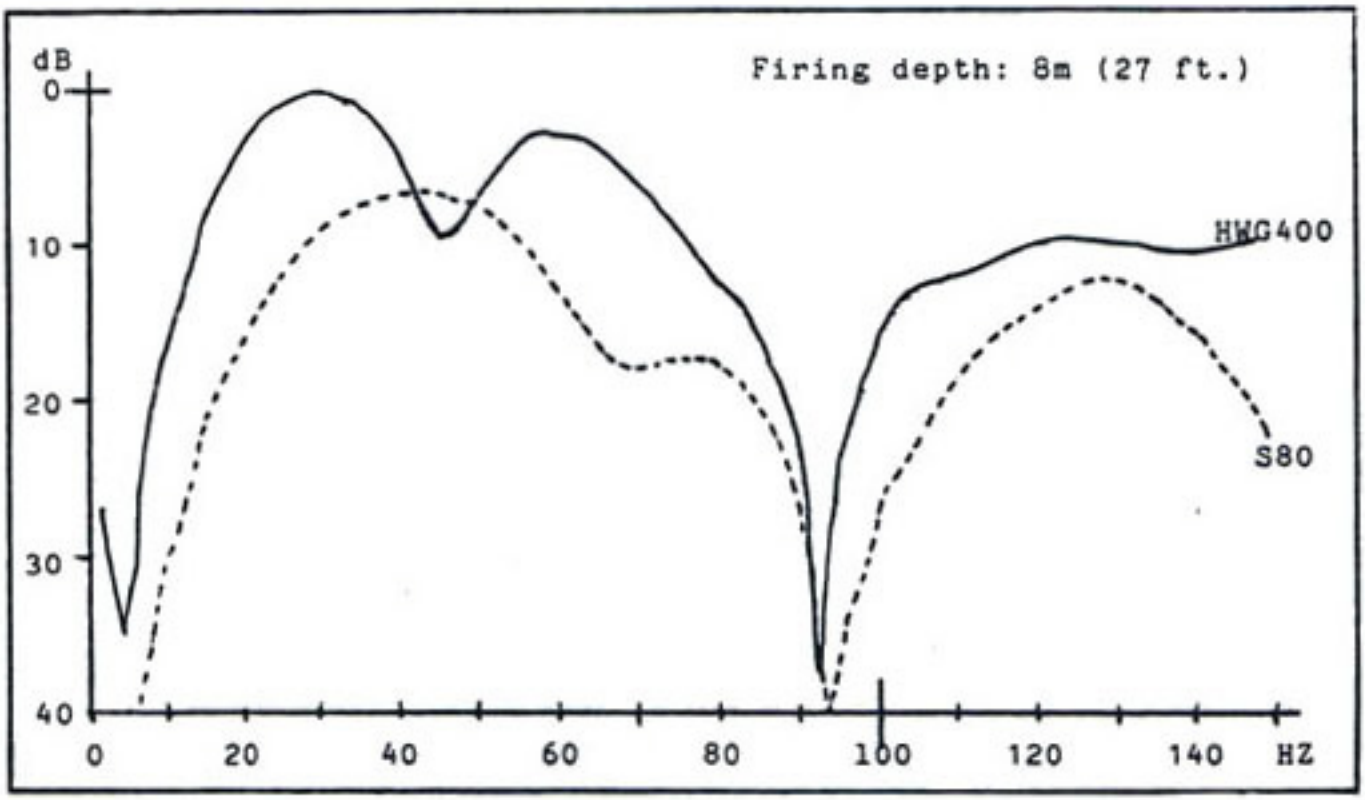
SIGNATURES & SPECTRUM COMPARISON



Conventional Water Gun
S80
2.2b-m/P-P-O-125 HZ



Hydropneumatic Water Gun
HWG-400
4.9b-m/P-P-O-125 HZ



CONCLUSIONS

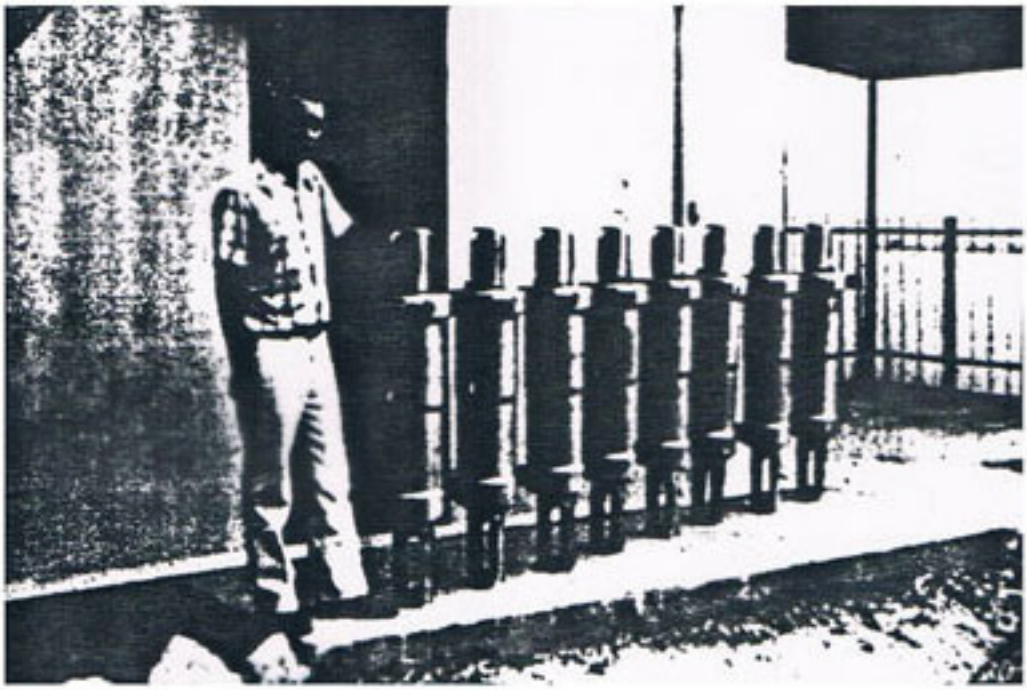
.The total acoustic energy released by one HWG-400 is four times the acoustic energy released by one S80.

1 x HWG = 4 x S80

PRAKLA-SEISMOS, Schulungsunterlagen

HYDROPNEUMATIC WATER GUN™

HWG-400



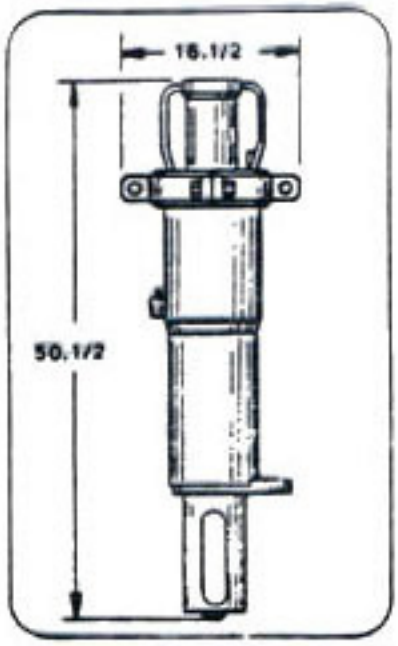
A JOINT DEVELOPMENT WITH SHELL COMPANY

The Hydropneumatic Water Gun™ system is a versatile marine seismic source system which can be operated either by compressed air or by hydraulic power and sea water-

- The use of compressed air is consistent with already existing compressors and leads to an important reduction of the number of Guns and of the consequent complexity of the towing system.
- The use of hydraulic power and seawater to energize the source leads to an important reduction of the power unit on board the vessel.
- The Hydropneumatic Water Gun is twice as efficient as any other seismic source on the market.

Seismic Systems Inc.
6300 Hillcroft, Suite # 610, Houston, Texas 77081
Phone: 777-7990, Telex: 762435

Seismic Systems Inc.



HWG-400

GUN SPECIFICATIONS

Physical:

.Material : Stainless Steel

.Weight : 350 lbs (160 kg)

Operationnal:

.Firing Pressure : 2000 psi (138b)

.Firing Cycle : 8 sec

.Firing Depth : 2.5 ft (0.75 m) minimum

HYDRAULIC UNIT SPECIFICATIONS

Length: 8.3 ft. (2.5 m)
Width: 3.3 ft. (1.m)
Height: 4.6 ft. (1.4 m)
Weight: 2,650 lbs. (1200 k)
Diesel Power: 40 HP

TYPICAL POWER REQUIREMENT

Using Compressed Air

.Air Pressure : 2000 psi (138b)

.Total Air Requirement at 2000 psi every 10 sec:

150 SCFM

or: 90 HP

Using Hydraulic Power

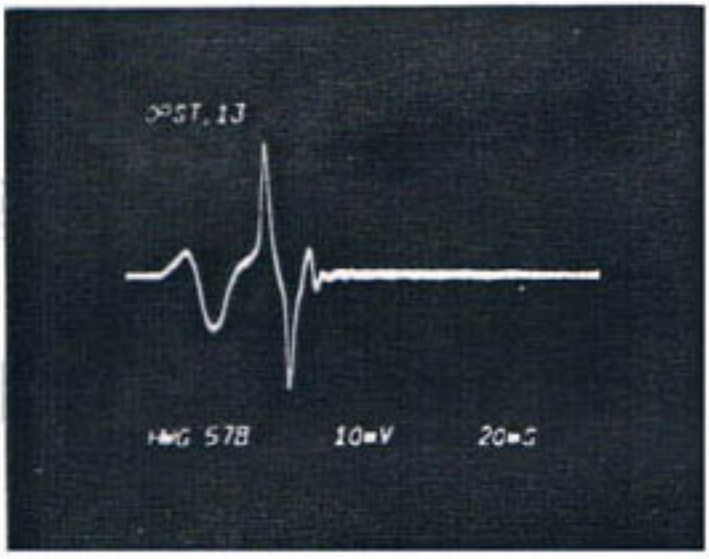
.Hydraulic Pressure: 2000 psi (138

.Total Flow Requirement at 2000 psi every 10 sec:

2 cu. ft/mn (56.5 L/min)

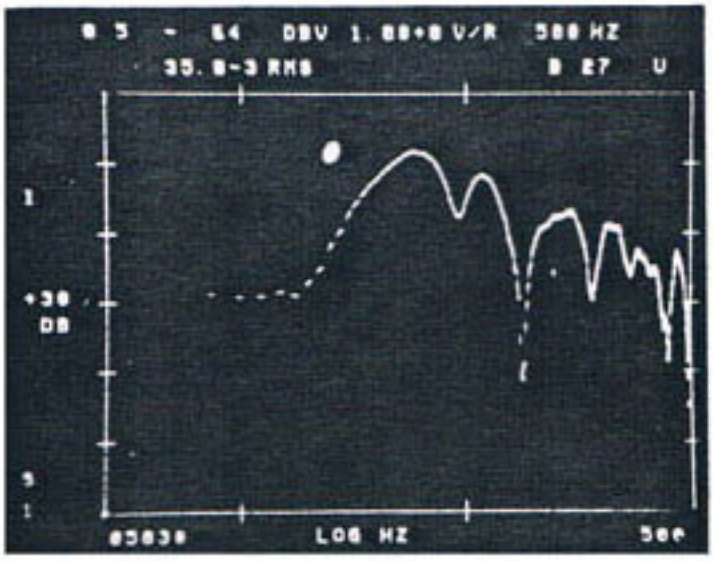
or: 40 HP

SIGNATURE



Horizontal: 20 msec/div
Vertical: 0.9 b-m/div
Filtered: 0-125 Hz

SPECTRUM



Horizontal: log 5/50/500 Hz
Vertical: 10 d3/div